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MECHANICAL INVENTIONS

AND

SUGGESTIONS

ON

LAND AND WATER LOCOMOTION,

Tooth Machinery,

AND VARIOUS OTHER BRANCHES

OF

THEORETICAL AND PRACTICAL MECHANICS.

BY LEWIS GOMPERTZ, Esq.

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PREFACE.

DISCOVERY and invention, whether in ethics, chemistry, mathematics, or mechanics, &c., as well as of the fine arts, are gifts bestowed on the few for the benefit of the many. When any new principle or plan (never known before,) has been found out, the discoverer may consider it a revelation from God, who has chosen him as the only one of the millions of the past, the present, and the future, to trust with the secret; and on this person unveiling the hidden treasure to the world, he bestows a blessing on millions of his fellow-beings, now existing as well as of future generations. It is, indeed, a matter of surprise, when an important discovery or invention is made, that it has not been made before; but it has been long in embryo, progressing circumstances have matured the fruit, and from the degree of force and rapidity with which the tide of invention may flow, may even be elicited some light as to the date of the origin of mankind. It is well known that in ages long past little discovery and invention existed, but everything produces its kind, and invention produces invention, which increases in a *parabolic* degree, its early progress being nearly on a level and varying by degrees into a sudden upward start.

This is not mere figure of imagination, but is the actual way in which invention proceeds, and it really does seem that by tracing its progress, as with the portions of a curve, we may find out every part, as "Hercules may be known by his foot," we may then see how long invention has been rising to its present state; also how much further it can go: and indeed it does seem that a time is rapidly approaching when it can go no further; and then it is to be feared that its talent will become a mere drug, while geniuses will prove without food for their body or mind, every thing being done, and nothing left for their thoughts to work on or to excite them into action. This is an evil we cannot prevent, but the result will be a golden harvest to the world. It therefore becomes the duty of every one, who has made any discoveries or inventions, to lay them before the public; and if the public refuse to reward him for his work, or attempt to rob him of its benefits, as is unfortunately generally the case, this must not be charged on succeeding ages. I have, therefore, however humble my suggestions, followed this dictate, in the decline of life, and when almost past the allurements of emulation or gain, but encouraged by several kind persons who have honored my long labours with their approbation, and though no helping hand has ever been held out to bring them into practice, a more favourable posterity may arise who might think them not unworthy its notice; and it is chiefly for the posthumous benefit that I now republish them, chiefly from the various periodicals which have honored them with a space, and should they prove of any use to futurity my object will be attained. I will, therefore, here lay them open, preluding them with a few general remarks on the principles of mechanical science.

MECHANICAL INVENTIONS.

MOTION AND REST.

All matter is still till moved by power; and in order to produce motion and impetus, four things are required; the first being *power*, the second being *time*, the third *imperviousness* of the body to the power, (so that the power does not pass ineffectually through it); and the fourth being the *vis-inertia* of the body or disinclination to be moved; this being a negative agent which *saves* the power, and lets it out the moment it is opposed; it being this resistance which enables the body to accumulate the power which has been exerted upon it, which increases as the time increases that the power is applied. Power, in a strict sense, can never be created by man, and all the power which does exist, it appears is indestructible and eternal. When, for instance, a weight is thrown up, and it falls to the earth again, it had continued to rise in opposition to the earth's attraction, but slower and slower till stopped; gravity, then, which had been overcome in the ascent, begins to pull it back again, slowly at first, but faster and faster, till it will have struck the ground, which will not let it go any further, but stops not the power it had acquired, the body being left motionless, while the power goes on without its incumbrance, and is then held by the earth in the same state as it was before it had caused the body to rise. From this may be seen the futility of the attempt to produce perpectual motion. Gravity has been generally supposed to exert a power of infinite velocity against matter; and whether this be infinite or not, it can do no more nor no less in the first second of time, whatever may be the material, than to move it 32 feet and a fraction; but the force of gravitation on a body is always in proportion to its quantity of matter, which is shown by the resistance its offers in a horizontal direction, this always keeping exact pace with its weight. The particles of bodies of great specific gravity cannot be of greater specific gravity themselves than those of small specific gravity, as then they would be smaller than infinitely small, which is impossible, and the particles of heavy materials must be closer together; if, then, it make no difference to gravity whether the material be heavy or light, which would seem by every body falling in the same time, it would appear that the strains or filaments of attraction are infinitely numerous and close together.

Time is also an essential object of consideration in mechanical subjects, and governs all operations; it causes the hardest bodies to become as if soft, and soft ones as if hard, as is instanced by a plate of soft iron cutting a body of the hardest steel, merely by revolving fast, so that a large quantity of surface in the plate is applied against one spot of the steel in a given time, which not being hard enough to cause the whole periphery of the plate to give way and be cut in that time, gives way and is cut itself; but if the speed be reduced the plate will be cut by the steel, the proportions of strength between them under different velocities being it appears different. The operation of time is sometimes difficult to comprehend; for instance, with regard to the force required to break strings of different lengths, no perceptible difference in time being required to break a long string (if inelastic) than a short one, though evidently in order to break the long one, we should separate more particles than to break the short one, as if the strings were of uniform strength in all their parts, they would not only break in one place, but would fly to powder.

FRICTION.

There appearing to be generally a little confusion as to the laws of friction, I will venture a few remarks. Considerable difference of opinion existing on this subject, some persons considering that it varies with the surface and velocity, others the reverse. M. Muschinbrook and the Abbé Nollet were of this opinion; Mr. Vince denies it, and his experiments have confirmed his view. He observes, in effect, that others have erred by judging of the force it takes to set a body in motion; as *cohesion* then forms part of the obstruction, but this remark seems not well founded, because cohesion has not been proved to act horizontally, and this seems very doubtful. It is true, that it may by its attraction increase the pressure, and thereby increase the friction; but it may add nothing of its own, though it increases the power of the other; that is to say, if the friction made no resistance to a sliding body, the cohesion would not, if I am correct. The difficulty to set a body at first in motion, seems to be that the friction holds it fast; and thus prevents the force from accumulating enough to overcome it: but, when once in motion, the friction gives way to the power, because the opposition of friction arises only from a certain number of asperities, and the power is continual. With respect to friction's not increasing with velocity, this, in one sense, seems true; friction being, as shown by him, a constant force: but this conclusion has led to a serious error, in making it appear that any velocity might be given to a body, in a given time, without increase of friction. If we calculate by time, the conclusion is just; but, if by space, it is fallacious. If we have to move a body a certain distance, the friction may be the same, slow or fast; but if we move it more space in a given time, the quantity of friction, as well as the velocity, is increased. There are also two species of sliding friction, which vary with different materials, and may have led to different conclusions. The one being when the asperities break, and the other, when they are surmounted. There is also a friction in rolling, independently of the centre; which seems not generally known, but M. Bossut was aware of the fact. I have found that in a brass wheel, a quarter of an inch in diameter, with an iron axle of $\frac{1}{8}$, well oiled, the wheel refused to roll on a smooth metallic surface, but slid instead; by which it would appear that in this instance the rolling friction was half as much as the sliding friction, the friction of the axle, which was half the size, making one half the friction, and the rolling the other. But in railway trains, the great number of carriages drawn by one set of engine wheels, shows the rolling friction here to be less: it being the sliding friction which would take place, if it slid, that causes a wheel when acted on, to revolve.

ON THE FORM OF COGS OF WHEELS.

On the first discovery of cog or toothed wheels, mechanical science having been in its infancy, the formation of the teeth was, without doubt, little understood: and, accordingly, a regular set of notches and projections, rounded off, so as to work as well as they could, was the ultimatum of the skill of the age, but which, for their simple uses, was sufficient. But, when more perfect equability is required, strict attention must be made to the shapes, which, as is now known, should be epicycloidal as to the teeth of the one wheel, and saw shaped the other (see Emerson's Mechanics), without which no regularity of motion can exist, the irregular velocities caused by common-shaped cogs, producing a tremor which nothing can prevent.

These epicycloid teeth are the remedy, but they only act one way, namely, while the pointed tooth is approaching or leaving the line which joins the radii of the two wheels; and, if a contrary motion be attempted, the pointed tooth comes against the wrong side of its fellow, it being the fact, though not generally known, that in perfectly regular motion, the same track is not pursued by the point in approaching as while leaving the centre line, while the wheels continue in the same direction, and the irregularity of a single straight tooth, if not interrupted by the next tooth of the same wheel, is always of two kinds : the one in *approaching*, and the other in *leaving*, the radial lines of the two wheels. But, with properly formed teeth, the points of contact *never* occur *twice* during the action.

In order, then, to act properly in either direction, instead of saw-shaped teeth, I employ *pins*, projecting from the face of the wheel, (fig. 1, plate 1), while the teeth of the other wheels (figs. 2 and 3), are epicycloids on *both* sides, so as to act correctly in approaching, as well as in leaving, the centre line ; the pin, or tooth, then, of the one wheel does not, as with straight teeth, enter against the beginning of the tooth of the other wheel, then proceed to the base, and leave it at the same point at which it had entered ; but it actually runs all round the other, as shown in the drawing (figs. 1, 2, and 3, plate 1).

The shape of the tooth will then be a groove, as shown in the diagram, fig. 5, pl. 1 *(a a)*. It is not, however, indispensable to have grooves, but the teeth may either consist of the external part alone, as in fig. 3, or of the internal part, as in fig. 2, (and if the two wheels, figs. 2 and 3, were put together, face to face, the two sets of teeth would fit and form grooves) ; but, if the full grooves were adopted, only half the number of teeth would be required, as they would then have a double action.

Figs. 2 and 3 show these wheels, of two constructions, each of them acting perfectly uniformly with its partner, however the teeth may differ. In fig. 3, the driving teeth act only while leaving the radial line, which joins the two centres, and in fig. 2 only, while approaching that line. In figs. 1 and 3, the pin wheel and the epicycloidal wheel are of equal sizes ; but in fig. 2, the epicycloidal wheel must be a little smaller than the pin wheel, because otherwise the teeth would diverge to a point, leaving no room for the pin's circumference, the centre of which describes the curve, and of course the circumference must then overlap ; but, by being a little smaller, each tooth gains a little in the motion, and causes the smaller wheel to keep pace with the larger. This causes the teeth to become broad at the point, so as to allow of being cut away to make room for the circumference of the pin. But, the plan fig. 3, by which the teeth drive or act only while leaving the centre line, seems far preferable to the other, fig. 2. And, when grooves are used, the epicycloidal wheel must be a little smaller than the pin wheel.

Toothed wheels may be so constructed that, though both wheels are of the same size, the curve or epicycloidal shall turn *twice to one turn* of the pin wheel. Fig. 6 shows the shape of *the teeth of such wheels,* which are also in grooves ; but *this* plan is more to show the theory, than for practical use, because the curvature of the teeth, though they appear to consist of two right lines, so nearly coincides with a circle described from the centre of the other wheel, that the slightest inaccuracy may cause the teeth to be real circles about that centre, so that the pin wheel could have no influence on, or transmit motion to, the other, because it would turn in the same circular course itself.

The most exact method to find out the curvature of the teeth is, to roll one wheel over the other, continuing the size of the curve wheel a little over the face of the other, so that the tooth of the other wheel shall mark it. But a more convenient method is this :—Describe a circle A N for the curve wheel, and divide it into twelve equal parts, T S being one twelfth, which twelfth must be subdivided above R into two ; and a circle, B M, representing the pin wheel, on which the pins are shown, must be described cutting the circle A N in the points T and S, and the interior part, above R, which gives the depth of the teeth. A circle, C M, must then be described from the centre N, passing through the centre M of the pin wheel, and twelve radii must be drawn from N reaching this circle. The twenty-fourth part, T R of the circle A N, must be divided into a number of parts, say 4, and through each of these divisions a circle must be drawn, making five circles from the centre N ; and these must be marked 1, 2, 3, 4, 5, as shown. Each twelfth of the circle C M N must then be sub-divided into four parts, and numbered as in the diagram, namely, 1-5, 2, 3, 4, on the outside, and the same on the inside ; but the 3 on the inside, to come with the 1-5 on the outside. The 1-5 is not meant for fifteen, but for one and also five, one and five being here to the same effect.

Then take in the compasses the shortest distance from the circumference of the small circle 5, to the large one C N M ; set one foot at 1-5 of the exterior figures, and with the other foot intersect the circle 1 ; then from division 2 to circle 2, then 3 to 3, 4 to 4, and 5 to 5, and this will sketch the general shape of the tooth (which must be completed by tracing the intermediate parts between the marks ;) and in order to get back again, set one leg of the compasses on 1-5 of the interior figure and the other in a corresponding circle, and mark as before. The whole tooth will then be complete, and the operation from the exterior division, 1-5 of the large circle to the small circle 5, showing the track of the teeth while approaching, and those from the interior showing how they leave it. This operation must be repeated for every tooth, which will produce twelve teeth, and between each tooth another must be placed, making 24.

Suppose, then, the wheels are regularly working the of way the arrows; the pin of the one wheel will, while approaching the radius of the two centres, trace the shape of the tooth, or work against its side, and trace the same of the other side while leaving this line; consequently, teeth made of this shape will cause the wheels to go regularly, and will also allow two wheels which vary in size to act together with the same angular velocity. The curves indicated by *p p* in the diagram are the shapes of the teeth of fig. 3, which act while leaving the centre line; and *c c* those which act while approaching that line, before it is cut away to make room for the circumference of the pin; and in curve *a a* the teeth act in a double capacity. The circle A N is a little smaller than B M, to suit the teeth which act while approaching the centre line; but for those which act while leaving that line, it is recommended that these circles should be of the same size.

To find the shape of the teeth in fig. 6, when the curve wheel turns twice as fast as the pin wheel, the same operation must be followed, excepting that the foot of the compasses in the small circles must be moved two numbers, while the foot in the large circle M N C is only moved one; and only six teeth are contained in this sort of wheel. B B in the diagram shows the shape of the teeth.

A very limited variety of motion, however, is obtainable by these plans; but by the means of my *pin and curve* wheels (discribed in my patent of 1815 in the "Repertory of Arts,") a greater latitude is given; they are explained in Plate 2. Here the pins B C D E, figs. 1, 2, 3, and 5, in the wheel A B are shown each in perspective with its partner, the axles and planes being so inclined to each other that the ends of the pins B C are beneath the surface of the curve wheel, and therefore enter into the grooves. But from the inclination of the wheels as the pins approach the point below D, or come to the line between the centre of the wheels, their ends come to the surface of the wheel so as to leave the grooves; and as they proceed towards E, they are so completely above the wheel as to pass over it without touching. The manner of action is this: the pin C is engaged in the groove G, and the pin B is on the point of entering H; by the revolution of the pin wheel its pins B and C act along the curved grooves (or *vice versa*), and thus the wheel turns its partner on its axis as with common wheels; and as the pins in succession quit their grooves (as the pin D may have quitted the groove K) the other pins enter the next groove but one, as B is supposed to be entering H. Before any pin, then, leaves its groove, the succeeding pin will have entered, and a constant action of the pins is thus kept up. The law of this *action depends* on the nature of the curves, which may be varied at pleasure, so that they shall turn each other with a perfectly regular motion or by a very irregular one, or these wheels may be made so as to turn with twice or four times the velocities of each other, or in other ratios; also to turn each other in different or similar directions to their own motion. Thus, in figs. 1 and 5, both wheels revolve in the same direction, as shown by the arrows, but in fig. 2, the curve wheel revolving twice to once of the pin wheel, the grooves are differently curved, and thus turn in contrary ways to each other. Here too the curve wheel, revolving twice to once of the pin wheel, the curvature is found in a similar way to the method just described, but exemplified in fig. 4. First describe the circle F L for the size of the curve wheel, then draw a circle A B C D for the pin wheel, and divide it into the number of pins it is intended to have, for example, twelve; subdivide the spaces between each of the pins D C and C B into any number, eight for example, and figure the divisons as shown next. On the centre F draw a circle through each of the said divisions, also a circle A R T passing, through the centre of the pin wheel. Now divide the circumference of this circle into as many parts as the wheel is to have curves, this will depend upon the ratio of the velocities of the wheels; thus, if it is to turn twice for once of the pin wheel, there must be half as many curves as pins; therefore in the drawing, the circle A R T is to be divided into six, and each sixth to be divided into as many equal parts as the spaces C and D were, namely eight. These spaces are to be numbered as shown. In order then to find the curves, take the radius A D in the compasses, and set one point in the division marked 3 between T and A, and make a mark at *g* upon the external circle, also numbered 3, towards that side where the curve wheel is to be elevated (by side is not meant side of the wheel, but the side of its position or space, as the wheel changes in turning from high to low) because it passes through the division 3 between B and C. This mark will be the first point of one of the curves; then from the division 4 mark the circle 4 for the second point, next from the point 5 to the circle 5; and so on through the whole number of circles. This will find a number of points, forming a curve G C *x*, which will be the centre line of the intended groove. And to find its breadth, describe small circles round each of these points, rather larger than the pins, as drawn. The edges of the grooves may then be drawn as tangents to these circles. The succeeding curves H and I are found in exactly the same manner from the succeeding divisions on the great circle, beginning on the division 3 between A R, and so on all round. On the opposite side of the circle are shown curves *g h i* proper for giving the curve wheel an equal velocity with the pin wheel, and there will therefore be twelve of these curves in the whole. The preparation is exactly the same, but the great circle, instead of six is divided into twelve, as at the points *a*, *r*, and *t*, and each of these are subdivided into eight, (or the same number as between *d* and C); the external part of the curve being surplus, then the curves are set out from these points exactly as before; in both these cases the wheels are considered as revolving in the same direction, as shown by the arrows 1 and 5. If required for them to turn each in opposite directions from the other, the curves must be reversed, as shown in fig. 2. To set out these curves, the same lines and divisions as in fig. 4 are used, but the division between T A and A R must be figured the contrary way, namely beginning at R and proceeding to A. Then setting one foot of the compasses at 5, between A and R, and the other leg in the first circle (marked 3) towards the side intended to be elevated, and as one leg is moved towards T, move the other leg towards the centre; and for the next curve begin with the same next number towards T, and so on, and mark as before. A reverse curve will here be produced, as shown dotted at *l* C *m*, and a wheel constructed with these curves as in fig. 2, will turn in a contrary direction to the pin wheel, (as the arrows show) and with twice its velocity.

Fig. 3 represents a curve wheel, with six curves; which therefore revolves twice for one of the pin wheel; but the curves are so arranged, that for two-thirds of its revolution the curve wheel revolves at the rate of four to one of the pin wheel, *viz.*, while the pins are in the curves G and K, the four remaining curves I L M H are close together, and the action of the pins when in them, only advances the curve wheel double the space of the pin wheel; but the motion of the curve wheel, even while the pins are acting in the grooves may be made irregular in various ways; thus, at the external parts I L M, where the pins first enter the grooves, are curved the same as fig. 2, and therefore the pins will in these positions turn the curve wheel twice as fast as they move themselves, but on entering and moving through the returned parts *i l m* of the curves, the pin communicates a recoiling motion to the curve wheel, which continues till the pin enters the last portions *t v w*, and at the same time a succeeding pin enters the next curve; this again actuates the curve wheel as in the first instance.

This wheel is set out on the same principle as the others, see fig. 6, which is prepared exactly as before, excepting the dividing of the great circle, which must in all cases be done according to the motion the curve wheel is to have. In the present instance it is first divided in 3 at A R S, and each of these subdivided into eight; then from No. 3 between R and A mark on the outside circle 3, from 4 to the circle 4, and so on till the curve G is brought as far as the next circle marked 3, from which place only move the leg in the large circle half a division; and set out K by following the same process on another part of the large circle, excepting that the leg in the large circle is continually to be moved a whole division. To obtain the other four curves, take the space from Fig. 3 *m* to 3*q*, which is one third of the whole circle, and divide it into four, *viz.*, at *m n o p q*; then each of these spaces being subdivided into four as shown by the figures 40, 50, and 60, produce the curves thus; begin at *m*, and mark on the external circle for the first division of H, then from 40 mark on the circle 4, and continue this till six circles towards the centre are marked, and the curve H is finished; this will have brought the compasses to one division beyond *n*; for the returned part *h*, mark the two next circles towards the centre, and by returning one division for each in the large circle; this brings the compasses back to 60, and advancing from that point begin the interior part *w*, and also the part M, of the next curve, which is completed by a repetition of the same process on the succeeding part of the circle, as is likewise L and I *i*; but the interior end *x* of the latter must be set out from the great divisions of the circle R S: thus, when the part *i* is ended from 60 next to q3, advance the compasses to the points 4, 5, 6, and 7 for marking the successive circles till the curve is completed, but this is only given as an example of the manner of making a wheel turn with a variety of motions.

An ingenious arrangement of the teeth of wheels has also been effected by Mr. White, so as to produce regular motion and avoid friction. Here the teeth are not parallel with the axis, but are askew, so that the action may be said to be always beginning and never ending, and so that no change of position or sliding takes place, but in this case the wheels require great breadth. Another ingenious plan for producing a species of variety of action is in the *hart motion* of silk engines. The shapes of the wheels not being circles, but being an eccentric figure, so that the superabundant surface of the one wheel fits the deficiency of the other, by which means the leverage varies as the wheels work.

RIGHT AND LEFT-HANDED SCREW WHEELS BANDS AND GROVES.

Instead of cogs, I have found that a right handed screw, cut on the periphery of the one wheel and a heft on the other, would communicate motion for some purposes, when a better plan is not at hand; but the simplest methods of giving motion is by means of bands, which should be of a V shape to prevent them from slipping, but which it will not completely do, and to remedy this I have curved the grooves into a zig-zag, and by which means a much firmer bite is obtained; the best bands however are chains with teeth and corresponding teeth in the wheels.

SCREW WHEELS AND ANTI-FRICTION NUTS.

Screws may not only be employed in communicating motion, but may be so arranged as to save the chief friction between screws and their nuts which I have heretofore described as my "*antifriction nuts to screws.*" Here instead of a common nut, a nut is formed by three rollers with a number of parallel grooves (not spiral) so as to fit the threads of the screw which works between them (Fig 7) P *l* 3, the turning of which causes the rollers to revolve (*or vice versa*), and thus is friction avoided. If the grooves in the rollers were spirals, the velocity would be double, like a screw with a double or with a coarser thread. Fig 8 is a method with only one roller, and a rod in the interior of the screw, which keeps it steady as it works up and down. The prevention of friction however here is not quite so complete.

COG WHEELS WITH UNLIMITED POWER OR VELOCITY.

I HAVE also to describe my arrangement of cog or toothed wheels, by which unlimited power or velocity is obtained by means of only four wheels (we may say only three), and also of turning in the same or in contrary directions as to their partners. This may be considered an extension of Watt's highly ingenious *sun and planet wheels*, and is as follows :—

A and C Fig 7 plate 1, are two wheels on the same axle, free of each other, and B and D are two concentric wheels on another centre ; but these two are fastened together, (or in other words are two sets of teeth on one wheel) so that the one cannot move without the other. All these wheels being fixed on a bar so that they work together, and if they were all the same size they would in no respect differ from the sun and planet wheels in their action ; but in order to produce a power or velocity unlimited by anything but friction and difficulty of workmanship, the wheels vary in size ; but the less the difference of the diameter of A on the one bar and B on the other, which work together, the greater will be the multiplying or diminishing power. If, then, we wish to give a very slow motion to C, A must be a very little larger than B, C and D being equal. The motion is then produced by keeping A and C stationary while the bar is turned round their centre, *which will* cause C to move very slowly ; because the wheel

B being a little smaller than the wheel A, it must evidently in rolling round it once, revolve round its own centre a little more than once; and wheel D being a fixture with wheel B. must do the same. But wheel D and wheel A being of the same size, C must also turn *a little* round its own centre in order to let D and C work together, while (the two being of the same size) the one turns faster than the other; the whole motion of C then consists of the surplus angular velocity of B to what it would have if of the same size as A which surplus might be so small that C might only move the hundreth part of a revolution to a whole revolution of the bar, while the wheel A is stationary, and the bar is turned round it, so that C would turn with great power. But if velocity be the object, then A must be fixed, while C is turned round by a handle fixed in its rim, which will cause the bar to spin quickly round while the motion of C is very slow. If we wish for one of the wheels to turn in the same direction as the wheel whose teeth it works with, C must be held fast, while the bar is turned round, in which case this motion will be produced; but it will be of wheel A, instead of wheel C, which will then be stationary. A fourth kind of motion results if the bar be held tight, and motion be given to one wheel by moving the one whose teeth works with it, but no difference of motion would be thereby produced between the two free wheels A and C, and this motion has nothing extraordinary in it.

The slow motion seems particularly applicable to cranes, &c. where great power might be wanted without much friction or complication; and the quick motion seems as suitable to clock work, &c.

READY CHANGE OF POWER IN MACHINERY.

It is remarkable that by the same arrangement of wheels as in the last invention, another object quite different to the former is obtained, namely, of instantaneously changing the action of lathes or railroad engines from a slow motion to a quick one, or *vice versa.* Here, too, the two wheels E F Fig. 9, plate 3, are fixed together and the two others B and C are independent. The drawing is meant to represent the wheel of a railway engine. E is the wheel, the flange being toothed as shown, but not so deep as for the teeth to touch the ground; and F is a small toothed wheel on the same shaft, and fixed to the wheel E, so that one cannot move without the other, and E and F may be considered as one wheel with a large periphery near E and a small one near F, and above this wheel are two toothed wheels B, and C, similarly sized to the former one but reversed in position, so that the large top wheel works in the small lower one, and the small upper wheel in the lower large one as shown. The two upper wheels B and C being free of each other have circular holes in their centres, through which a round axle passes, which is loose in the wheels as well as in the pillars, and upon which either of these wheels can freely turn ; but either of these can be made fast to the axle which passes through them when required by means of two small screws D D, which go through the nave, and by pressing against the axle, which may have a number of indentations if necessary, and should be larger than shown, and this causes the wheel and the shaft to be fixed together. The same applies to the upper wheel ; and A is the crank to which it is applied. Now, suppose we are going on a level road, a fast motion will then be wanted, consequently, what we have to do is to tighten the screw of the large wheel, and loosen that of the small one, by which means the large upper wheel alone will act on the small low wheel, and thus cause a quick motion ; but in going up hill the reverse is to be done, the screw of the large wheel must be loose, and that of the small one tight, and then will the small wheel above drive the large one below, and thus cause a slow motion. There might be more motions than two if required, by having more wheels. This mode of rendering the wheels tight seems very efficient for turning lathes, but probably for railway engines it may not be the best way ; a hollow cone might, in such case, be screwed between the box and the axle projecting beyond the axle, instead of the former screws.

ON THE SETTING OUT OF COG WHEELS OF DIFFERENT SIZES.

MANY practical mechanics, being at a loss how to set out their cog wheels, it may not be out of place to explain that they only have to draw each wheel which is divisable into a given number of teeth with its partner of the relative sizes, leaving the depth of a tooth between them, then to draw another circle round each of their centres, cutting the teeth into two halves, in which case these two intermediate circles will be in contact, the two top circles will then be the ends of the teeth, the middle, and the lower ones the roots of the teeth, which are then easily made to interlock. The size of the wheels being taken by the middle of the teeth.

LAND LOCOMOTION.

SLEDGES AND CARRIAGE WHEELS.

SLEDGES being the most simple instruments of land transit *were no doubt* used first ; wheels may be considered as the improvement upon them, and great is their advantage, yet the advantage has been greatly overrated, their superiority consists *only* in *avoiding friction.* But they do *not* act as mechanical powers to reduce draught in the way generally imagined, on the contrary, they are in this respect inferior to well shaped sledges, the ends of which can be turned up so as to raise the load over obstacles more gradually than wheels do, and do not sink into holes as is the case with wheels. A wheel does *not* act as a *lever* in surmounting an obstacle, and it gains nothing whatever by revolving, or in other words by *being a wheel*, excepting the avoidance of friction, and if it were chained fast, so as not to turn the obstacles would be overcome in the same way as if free (excepting friction).

Suppose A B C 18 be a wheel which meets an obstacle A E the pheriphery will then not (as when on level ground) change its point of contact with the obstacle now forming the road, but will fix the radius A C upon it, and form the arc C F the same size as the wheel itself, and then the periphery will be neutral. If, on the other hand, the wheel *could not revolve* precisely the same circle C F would be described by the sliding of the part of the wheel A B over the point of the obstacle.

For suppose the radius C A turn on A, the end or centre C will then, as before observed, form the segment C F every part of course being equidistant from the obstacle during the action. And if the wheel did not turn but was guided by the sliding of the part A B on the point A, the centre C would also then be always equidistant from the obstacle, because it would always be touched by a part of the circumference, and as the velocity would not differ, the two actions would in every respect, barring friction, be the same. It is, indeed, only by *friction* that the wheel could turn at all. If the periphery were perfectly free from friction, no force, however great, could cause it to turn, neither the hand of a man nor a cannon ball, as no other direction of force could thereby be given than from the circumference to the centre ; but never in any degree as a tangent.

On hard or level ground (like railways) wheels travel with great facility, but when obstacles are opposed it is far otherwise. None of the lifting force, however, which is exerted to raise a wheel over an obstacle is lost, the whole being regained in the descent ; still the obstacles are the chief causes of the labour required in the draught, and it is to the quantity of matter instead of the weight that the loss of power is owing, as every abrupt obstacle causes a sudden change of motion and a blow, and it is this that does the mischief, which has nothing to do with gravity (taking one obstacle with another). The softness of ground also causes a great and continuous obstruction to the action of wheels, and the more so the more the road is inelastic. What with obstacles and softness of ground, then, carriages on common roads move with great labour compared to that of railways. In order, then, to avert these evils of wheels, I have suggested several descriptions of machines, which are experienced as follows.

The main principle in all of them being the same, namely: by their proceeding on feet and stepping over the obstacles.

SCAPERS, OR WHEELS FOR ESCAPING OBSTACLES.

THE first of these attempts has only a partial effect. Figure 11. plate 2, is an end view of the carriage where A is the bed to which the axletrees are usually affixed, and on these are fitted a small pair of wheels B, to be supported upon the upper surface of two large nearly horizontal wheels C N, C N revolving beneath the bed A upon axles projecting downwards from it, and inclined to each other as the figure shows. These wheels have legs D. fixed beneath them at different points of their edges, which bear upon the road, but by the inclined position of the wheels C N they only touch when at the position X Z, being raised off the ground when at other positions as shown. Therefore, the legs D as the carriage advances, support it at X Z, by the wheels B B resting on the upper side of C C; and as these revolve on their axles, others of the legs are brought successively into action, while the former ones are carried off the ground and taken forwards to be employed in turn. The wheels C N may if required have cogs on their edges to turn each other, and they must be so put together that the legs of one when at V clear those of the other. The legs have feet rollers; for, as the legs revolve with the wheels C N, the feet do not remain in exactly the same position on the road while the carriage bears upon them, but move laterally a little, yet no lateral motion is necessarily communicated to the carriage by this, because, by the connection of the wheels C N it takes place in the opposite sides X Z, at the same time, and each counteracting the other; the feet wheels also allow the carriage to move sidewise, other wheels may be attached to the carriage to bear upon the disc C in the same manner as B, but at different points, where found necessary as shown by the dotted circles L. This plan may be applied as castors to furniture. The motion produces a slight rising and falling of the carriage as the legs pass, but it might be remedied by curving the surface of the disc C accordingly. The wheels being allowed to rise *and fall freely* upon their axles which are in the beam A.

The second plan of these machines is superior. Here the legs are not horizontal but perpendicular. Figs. 1 and 2, plate 4, show this wheel in two positions, each of which consists of four radii or legs revolving on a centre or axletree in the usual situation, which radii can extend and contract in right lines to and from their common centre, and by means of certain curves hereafter explained, they contract and extend by such a law, as to support and advance the centre always at the same height.

Figs. 1 and 2.—A is a square frame, revolving on a centre or axle M; each side of this carries a block *a*, *a*, *a*, *a*, fig. 1, which supports the joints of a frame or parallelogram B B, and C C, the sides of which are jointed together as in the figure, and each carries one of the legs marked D V, which in turn support the carriage, as shown at Z, fig. 1, and X, fig. 2. These jointed frames, by opening or shutting on their joints, allow the legs D V to advance or recede from the centre; and the legs have wheels, E E, attached to them, which constantly apply to the curve F G H I K, which is fixed to the carriage; and, as the whole revolves on the axle M, the extension and contraction of the legs are thereby effected. Thus, in fig. 1, the leg D Z, is at its greatest contraction; and its wheel E, is at the highest point of the curve. From this position, as the carriage advances, the curve H proceeds to the left of the figure upon the wheel E, till it comes to the position of fig. 2; by which time, the succeeding leg X has reached the ground, and its wheel E comes beneath the curve to support and advance the carriage; the leg Z, having now become useless, is gradually lifted off the ground, by the turning of the wheel (or substitute), guided by the rising in the curve from I to K, and carried round in the manner shown by Y, upon the circular arc L L, till it again comes to the ground in front, to support the carriage.

As the parallelograms B C are not so strong as to support the carriage, when in the inclined position, as X, fig. 2, a second wheel, N, is affixed to each leg; and, in the lower part of its revolution, applies itself to the top of an interior curve O P P O. This curve being so adapted to the other, that in all positions of the motion, the wheels N and E keep close to them (their respective curves). R S S R is a third curve, applying to the upper side of the wheels N. The grooves in the edges of the wheels N and E, embrace the edges of their respective curves, and thus are all parts kept in their places, and for the same purpose the interior curve is continued all round, as shown at T; a small curve is fixed on the front of the great one, as shown by the line *s s*, and a small roller *t*, is fixed to the back of the leg, to run on the upper side of this curve, and keep the wheel E close to its place. This curve is not essential, but is a precaution against any looseness in the parts; and should not be put on the other curve quite flush, but so that the rims of the wheels in the legs can get between them. The feet, or extremities X Z and W Y, of the legs, may be of any form, adapted to the ground; or they may have small wheels, as shown at W Y X Z, which will allow the carriage to move sidewise. These lateral wheels might, if required to be larger, incline as in Z, fig. 9, and *r* and *r* are cups to protect the works from dirt. The curves F K, &c., are supported as shown in fig. 1 and 2, by brackets or stays *p*, from the carriage.

In order that the legs shall extend and contract in right lines, the two sides of each parallelogram of the legs, have small-toothed circular racks, which work together shown at *e e*, fig. 2, which causes each side to make the same degree of motion, similar racks are also applied to the lower joints; or, instead of these racks, I use an iron, with a properly curved groove in it fixed on one side of B and of C, as shown at *g*, fig. 1, in which a roller fixed in the opposite side works; and thus also is a rectilinear motion obtained, each leg is also provided with a forked iron K, which, when the legs are contracted, embrace the shaft of the axle behind the wheel, and keeps them right.

Fig. 3 is an edge view of one of the wheels, the same letters denoting the same parts. It shows the thickness of the parallelograms B C, the frame A and blocks *a*, the axle M; also the situation of the leg D V. The part V being behind the parallelogram, and united to D by bolts, and the wooden block *m*. K is the fork, and E N the two wheels, which run under and on the curves. They are placed behind the leg V. The foot-wheel W is attached to the end of the leg V, by crooked irons, which bring the centre of the wheel into the plane of the wheels E N, that the weight may be borne as fairly as possible.

In order to find the curvature of the curves F K O R and *s*, all the parts (but the curves themselves) are put together, and placed horizontally, with a flat thin drawing board beneath them, in the place where the curve is to be. Upon the centre pins of one of the wheels, fit a wheel of lead of the same diameter as the wheels, and fix a straight board to represent the ground; but at X and Z (forming the span of the wheel when square) the board is to be curved upwards, as shown dotted at X V and Y Z, in the same gradual way as the feet ought to meet the ground. Now turn the wheel round, sliding the foot on the straight board and its approaches, and the leaden wheels E and *s* will blacken the board behind, so as to show *the true shape of* the curve, including the approaches.

To find the curvature of the little irons, *g*, fig. 1, which guides the feet in a right line, fit up the leg, as if actually at work, and, by any means preferred, move it backwards and forwards, and let a little leaden wheel also trace out the shape on a board, fixed on the other joint.

Figs. 9 and 10, pl. 2, is another method of contraction and extension of the legs in right lines. Fig. 9 is an edge view, and fig. 10 a front view, of two legs, M. A is the central frame of the wheel, its sides *a*, *a*, *a*, *a*, form joints or hinges for other frames, B; these, again, are connected to a second set of frames, C; and these, at the opposite ends, carry legs like fig. 1, pl. 4, which fold up, as shown at Z, and the opposite ends being extended. The joints C B and L N, being perpendicular to each other, they prevent a deviation from a right line in any direction.

Figs. 4 and 5, pl. 4, show another carriage for escaping obstacles; and which I think preferable. Here the legs do not contract and extend in themselves, but slide across the centre of the main axle M. Therefore, the contraction of one foot is an extension of the opposite one. D E F G, fig. 4, are the four feet, of these bars, which are attached to a central wheel, A A, fitted upon the axle M, and bearing eight grooved rollers, marked *a*, which guide the motion endwise. Each bar has an opening in the middle, to admit the axle without touching it. The bar F G lies before the other. The bars have wheels, shown by the dotted circles H I K L, attached to them behind, which apply to the curves which guide the motion. Now, if the centre of the upper of these wheels is, by any means, made to move in the proper curve for advancing and supporting the carriage, similar to what is described of fig. 1, and shown by the dotted line N *n* N, the desired effect will be produced. And when the bar F G comes to an angle of 45 degrees from the perpendicular, if the circumference of the same wheel be guided by a curved iron, P Q R, on one side, and the opposite wheel, L, up a corresponding curve on the other side, the bar will be carried off the ground, as shown by E D, fig. 5, until the foot F, fig. 4, reaches the ground, when the centre of the wheel L enters the dotted line, curve N, and the other bar acts in the same way as this. The centres of the wheels K L may be made to move in the curve N *n*, by forming a curved iron, of a proper shape to guide them, and applying it to the circumference; but the means which I prefer (as possessing less friction) is shown in the drawing. T is a centre pin, supported over the main axle M, by the frame of the carriage, and by a standard *b*. On this, as a centre of motion, the bar V (which I call a curve bar) revolves, and *attaches* either of the wheels H I K L to the end of it, as shown by the figure, and hereafter described. It will be found by inspection, that this dotted curve approaches very nearly in figure to a circle, which would be described as the end of the *curve bar* V, but the difference is completely rectified thus.

The curve bar is made, as shown in figs. 6 and 7, with a groove through it for a great part of its length ; *d* and *e d* are two elbowed sliders, behind the bar, with projections, *c*, coming through the grooves, fig. 7, to guide the sliders in a right line, to and from the centre. In front of the curve bar, each of the sliders carries a lock *f g*, (see fig. 8) for the reception of the wheels I K, as shown at figs. 4 and 5 ; or rather for an additional flange, which it ought to have. Each slider also carries a wheel *h i*, and being formed, as shown in fig. 7, the wheel of each slider is fixed on the opposite sides of the centre T, to the lock which the same slider carries ; thus, when the wheel *i* of the opposite slider *d*, is by any means thrown out from the centre T, the lock *f*, belonging to it, is drawn towards the centre. The necessary motion is given to the sliders and locks, when in action, by a curved iron, dotted at *k*, which is immoveably fixed round the centre pin T, as shown in the other figures, and the wheels *h i*, in revolving round upon this, being kept near it, by a larger curved ring, *m m*, which surrounds *k* at such a distance as to form a complete groove between the two, and in which the wheels run ; and both curves are so formed, that the centres of the lock *f g*, describe the intended dotted curve N, fig. 4, when the curve bar V turns on its centre T. The wheels I K are held fast in the locks *f g*, by means of a bolt, figs. 6 and 7, which confines the outside of the wheel K, holding it fast by the lock, which is formed, as shown in fig. 8, for its reception, and is screwed or pinned fast to that part of the slider which comes through the groove of the curve bar. The bolt of each lock is guided by having two projecting parts, *p* and *q*, which enter corresponding holes in the back of the slider ; and to lock and unlock them a curve, *r s r s* is employed ; this being a ring nearly concentric with *m*, fig. 4, but its upper and lower halves are not in the same plane, the lower half being bent backwards at the point *r r*, fig. 5, as shown by the dark shaded parts (represented in the plate), taking care that the curve does not rub against the hook of the bolts *q* (which embrace the ring) when the wheel is fairly seated, and when the lock is upwards, as *g*, fig. 4, the bolt is kept forward by the ring *r*, fig. 6, and holds the wheel K fast in it, (shown in the upper end of fig. 6;) but, when the lock comes round to the part *r*, fig. 5, the bolt is withdrawn, as at the lower end of fig. 6, which allows the wheel to escape from the lock.

The operation of the whole machine is thus :—Suppose the *carriage is supported* on the foot G., fig. 5, the wheel K of the same bar, which turns round with it as the carriage advances as before described. By the wheel *h* of the curve bar bearing on the curve *k*, the lock *g* moves in the dotted curve till it arrives to the position fig. 4. The foot D is then coming to the ground, while the opposite wheel I of the bar is guided by the part O P of the curve into the lock *f*, the bolt thereof being held back by the curve *r s* until the wheel I is completely seated in the lock, and then it comes to such a part of the curve *y* as to force the bolt forward, and hold the wheel fast in the lock: soon afterwards the foot D, by the guidance of the curve O, P, Q, R, S, and the motion of the curve bar, comes upon the ground, and takes the support of the carriage. The wheel K of the other leg F, G, now entering the guide O P Q R S, the bolt being withdrawn to relieve the wheel from the lock *g*, and it travels down the curve O P Q R, soon after which the wheel L goes up the similar curve S R Q P, on the other side, in the same manner as E D (fig. 5). These curves are so formed, that as the whole revolves they draw the foot E, fig. 5, towards the centre, and extend the other D, till, at the horizontal position, both feet, D and E, are equally extended. From this point they continue to draw in E and extend D, until it arrives in the position of D E, fig. 4, the foot D being ready to descend to the ground, and the wheel I to enter the lock *f*, to be carried round in the dotted curve by the motion of the curve bar and slides as before described.

The form of the parts of this machine are apparent from the drawing. The curves O P Q R are supported by braces *p* from the bed of the carriage, and the other curves *k m* and *s* are supported by the framing of it, as the figures show. The main axle is cranked downwards, between the wheel and the body, without which the curve bar could not pass, and the ends of the bars D E F and G are bent or elbowed backwards so far that the centres of the feet-wheels D E F and G are in the plane of the curves O P S, to take their bearing firmly. The wheels I K L and H have each two parallel grooves in them; one to embrace the curve O P, and the other to be engaged in the curve bar: these two grooves being at a proper distance asunder, to admit the latter to work behind the former.

To set out these curves, I put the machine together without the curves, and place it horizontally, with a ruler for the ground line; which, like in the last machine, is straight from *x* to *z*, fig. 4, omitting the wedge parts, which there leads the feet to their bearing, because in *this* machine it forms its own course of meeting the ground. In the place of the small curve *k* I fix a drawing-board chalked. Then by engaging one of the bars, as F G with the lock *g*, and turning it round while the foot G of that bar is slid on the ground line from *x* to *z*, the wheel *h* of the curve bar *v* will trace that portion of the curve *k* which is below the centre T, the upper part of the same curve being found thus: when the feet come to the ends *x z* of the ground line, the curve bar *v* is parallel to the ground line, and the bar D E and F G will make an angle of forty-five degrees with it. In this situation engage both bars with the locks *f* and *g*, and tracing one of the legs, as G along the ground line towards the centre, it will give such a motion to the other bar E D as will take the foot D off the ground in the proper inclination, and the wheel *i* will trace out another portion of the curve, and by a similar motion of the other leg this curve is completed on each side. The remainder or top part will be finished by an arc of a circle described from the common centre T. The curve *k* being found may be finished, and then the others may be found as follows:—*m* will be traced on a board properly fixed, by the outside of the wheels *h* and *i*, as they roll round the other *k*: and in the same manner parts of the shapes from R to S, and also from O to P, will be set out on proper boards by the wheels I and K, while they continue to be guided by the curve bar *v*; but the remainder is thus obtained: set the bar E D horizontally, and place its feet equidistant from the centre, marking with the wheels I and H the two points Q of the shapes, and from these to P draw a gradual curve, like the drawing, taking great care that no abrupt changes in its form exist, and in the parts leading to O P and P O particularly great skill is required in determining the form of this curve, which leads to the locks, and cannot be done by rule, but by discretion and trial. The part R S of the curve is determined by the part O P by the same motion, and is traced out on a board as in the former plan.

This method prescribes the exact curvature at which the feet meet the ground, which will scarcely admit of variation, and causes the chief defect (in this last-described machine), as it causes the foot D and G to vary their distance from each other, while D is meeting or leaving the ground, which if unlevel, so that both feet touch at once, produces a *drag* between them; but this only occasionally and temporarily occurs.

Another, though an inferior plan of these wheels is as follows. In this machine the legs do not contract and extend, or slide or roll across the centre, but the effect is produced by the motion of the wheel itself, which is a fixed but revolving square: *a a a a*, of figs. 3 and 4, pl. 5, is the frame of a carriage with two of these wheels in different positions; A B C D are two *crosses*, strengthened by pieces *b c d e*; the ends, *f g h i*, of the crosses being circular and broad. These crosses travel on each foot alternately, but have the imperfection of rising and falling themselves, yet not permitting the carriage to do so, this being effected as follows.

P Q, fig. 10, is a double axle parallel, and in opposite directions, whose parallel distance from centre to centre is exactly half of the distance that the cross rises and falls when travelling. The longest axle, Q, goes in a box or tube in the carriage, and axle P in a box in the cross; and this double axle makes a whole turn at every change of foot; so that when the leg which is on the ground is perpendicular to it, the axle P is full *upwards*; and when the two feet touch level ground at once P is quite *downwards*. The centre, then, of the cross will revolve in a circle, whose diameter is the exact length of the rise and fall; by which means, though it rises and falls itself, it does not allow the carriage to do so. Besides this office, it performs another, by causing inequalities of ground to be more gradually overcome, which a mere up and down motion of the centre would not effect; but the nearly horizontal motion of the axle when downwards causes the carriage to yield horizontally to the obstruction trodden on. The motion then of the cross is guided as follows. E F G H are four wheels, one on each leg, which are controlled by a properly curved iron, I J K L M, fixed in the carriage, and this curved iron alone would do without the crank, were it not for side-pressure.

In order to project this curve, draw a straight line *o k*, fig. 1, plate 6, equal to the span of the feet taken from the little circles *f*, *g*, *h*, *i*, and also draw the cross with the wheels and centres, and letter them as in fig. 1, plate 6; divide this line into a number of equal parts, call the middle of it 1, and figure (towards the letter O) 2, 3, 4, 5, 6, 7, 8, 9; and towards *k*, mark 16, 15, 14, 13, 12, 11, 10, and 9. Then draw circles the size of the feet round each of these divisions, and also draw a line *k f c*, touching them to show the ground. Then from *g* erect a perpendicular *g i*, the height of the cross, and at the upper end also draw the foot circle *i*, as on the cross, and bisect this line shown at P, also placing No. 1 at the point of bisection; then take a space in the compasses from this point P or 1 *downwards*, equal to the parallel distance of the centres of the axles P and Q, fig. 10, plate 5, and mark a point Q on it. Then draw a circle round the point Q, through the middle P, of the perpendicular *g i*; and then take the distance of the top P of circle P Q to No. 1, in line *o k*, in the compasses; fix them at No. 2 in line *o k*, and intersect the circle P Q in an opposite direction, with the same distance; next from No. 3, line *o k*, and proceed in this way to No. 9, and in the opposite directions of the circle P Q and line *o k* also, and mark each intersection of circle P Q; continue by numbering the intersections from 1 in the direction P, M, K, P; 2, 3, 4, 5, 6, till 16. The little circles (representing the axle in its various positions) being drawn in the diagram round these points; and draw right lines the length of the cross through each of the points to touch line *o k*, at the same numbers as those of the points which they pass through, representing the legs when they are most perpendicular in their different positions, and the dotted wheels *x x x y* show the position of the leg wheels when two feet at once touch level ground; the upper circles 1, 2, 16, &c., show part of the direction of the motion of the upper part of the cross, which, if continued, would form a loop on each side, while the lower feet go in a right line. Then take the distance of the centre of the leg wheel *v* to *g*, line *o k*, in the compasses: fix one compass leg on each of the numbers in line *o k*, and with the other leg mark the lines which are of the same number as that in which the compasses are fixed; this will give all the main part of the curve *x y* described by the centres of the leg wheels, while these wheels bear the chief weight when the ground is level, and which may also be found by measuring from the circle P Q, taking the distance *v* P instead of *g v*, and proceeding similarly from the numbers as described, marking each of the lines which are between *x* and *y*.

The use of the remainder of the curve is to keep the axle P of the cross, and crank P Q in its proper direction and velocity, also to support and guide the cross when the feet come on unlevel ground, and is found thus :—

Take the distance *x y*, of the intersections on each of the lines 9 in the compasses, fix one leg of them on 9 *y* line *o k*, and mark a part of a circle *q* beyond *x*; then fix the compasses with the same span on 10 line *o k*, and mark another part of a circle *q* a little beyond the last, and so on with Nos. 11, 12, 13, 14, 15, and 16; then take the distance from 9 in the circle P Q to the intersection 9 *x* in the compasses, and fixing one leg on 10 in circle P Q, with the other point intersect *q* 10; then from 11 in circle P Q to *q* 11, and so on to *q* 1 inclusively, the centre line from the axle of this side of the curve I J will then be found, and the side M L is similarly projected, first with the span *x y* beginning from 9 *x*; then from line 8, and marking beyond *y* next at 7 in the same way to 1 inclusively; and number them 8, 7, 6, 5, 4, 3, 2, 1; continuing by the same relative numbers of the line *o k* and circle P Q as before. The whole curve then, that the centres of the leg wheels describe on the machine, will thus be projected; arcs of circles then the size of the leg wheels must be drawn round all those points, and the tops will show the curve which governs the motion. The lower part of the curve J K L may also be found by a leaden wheel and a board as described in the former machines.

This plan is not adapted for quick motion, as the cross rises and falls (in itself) too abruptly, but for heavy and slow draught this is not so objectionable, and a spring being applied to the crank to raise the centre of gravity of the cross, mitigates this evil. (See "The Repertory of Arts," June 1821.)

Fig. 3, plate 3, is a curve bar which might be substituted to guide the wheels, instead of the curve I J K L; excepting a small portion of it, *u* is the centre of its motion, and *a a*, *c c*, and *b b*, and J J K K *l l*, and *g g*, form two grooves, the cross then having two rollers in each leg which work therein, and are thus guided in a right line. For the detail of this plan see the "Repertory of Arts" for June 1821.

A far superior machine to this one or any of the last is the following:—

Here, as in the third plan, the guiding curve is produced by a combination of motion instead of by an actual curve, and thereby reduces the friction. Figs. 1 and 2, plate 5, show it in two positions, and each consists of a parallelogram of four outside pieces, A B, *w u*, C D and *y* V joined together at *y* V, *u*, *w*. E G, H F, are two cross pieces jointed to the middle of each of the former pieces, A B, C D, *w u* and *y* V. The cross pieces E G, H F, have a hole through their middle with a box for an axle to go through, which is fixed on the carriage, on which the parallelogram is fixed as a common wheel, and on which it goes. These eight joints V, G, *u*, F, *w* E, *y* H, allow this frame to expand and contract, and constitute the chief of the wheel; turning round as it goes, and continually opening and shutting, by which means it runs without rising and falling, A, B, C, D, are four feet, each being a quarter of a circle or a little more, described in fig. 2, from the centre of the joint which is near it; and in fig. 1, from the rolling axle of the joint (described hereafter) so that some part of the foot is always directly under the joint, but the feet should not be larger than can be avoided; two feet are formed on one side D, G, C, and two on the opposite side A, E, B, the two other sides being without any; these feet will cause some difference in the motion of the centres of the joints, according to when the parallelogram bears on the right or on the left end of the foot, in one case the part of the foot which bears on the ground being guided by the side to which it is attached, differently to what it is in the other case, and occasions a difference of velocity with which the parallelogram will turn, while that of the carriage remains the same. This, however, is of little consequence, excepting that it requires the feet to be made accordingly, by being only on two of the sides and none on the other.

This frame, then, being a parallelogram, whatever motion is made by one joint the one which is diagonally opposite to it will perform a similar motion, and therefore if a straight guide were placed near the top of the parallelogram, and four small wheels were fixed on the joints V, *u*, *w*, *y*, so that it bore on the top of this straight piece, then would the parallelogram be properly guided without raising or lowering the carriage when on level ground; and in order for this same motion of the parallelogram on the axle to be preserved, when any occasional obstacle is met by the foot which is coming to the ground, a straight piece might, if preferred, be also fixed to the carriage, so that the little wheels on the joints press upwards against it, and so that these little wheels would run between the two straight pieces; this top piece would guide when the parallelogram is rising to the top of the obstacle or, if a depression, while it is sinking to the bottom of it, and would raise or sink the carriage gradually, and be only of use when such impediments acted against the foot that was coming to the ground, and the bottom straight piece be acted on only when the ground which the feet were meeting was level, whatever the ground between the feet might be; but a better way of guiding the motion than with straight guides, as possessing less friction, is as follows :—

When the top and bottom joints *v* and *w*, fig. 2, plate 6, describe right lines on the carriage as it travels, the intermediate joints *u* and *y* form curves, relatively to the carriage, which very nearly resemble parts of circles on both sides, drawn through the two points of the centres of the joints *v* and *w*; when the parallelogram is square, and through another point 9 where the joint is, when fully extended, as fig. 2, and the same applies to the other side of the diagram. This diagram contains the circle, and the true curve also separately shown, with the difference between them; the true curve being numbered from 1 to 16, and small circles being drawn to show the axle of the joint as it goes; it is then obvious that if these joints, which are not on the ground, be by any means guided in this curve, the top and bottom joints will also be properly guided; and it is by applying a guidance to the foot which is not on the ground that the motion is governed, because, as the shape differs little from a circle, we can interpose a radius or arm J T O S, from the centre of each joint to which it is fixed (free to turn) to nearly the centre of the circle, which the curve resembles; and to draw a small curve partly round it of such curvature, that when the arms are by any means pointed to the centre of the circle, in fig. 7, which is also the centre of the large circle in fig. 2, while a pin in the end of the arms properly follows this curve, then will the joint it is attached to be guided in the curve 1, 3, 15, 16, &c., in the same way as if it were guided by the curve itself, but avoiding the chief friction. The shape of this curve, however, is such that it would not restrain the arm in a line with the centre, and consequently would allow the pin, instead of following the shape of it properly, to fall to that part of the curve which would give the greatest extension to the joint to which it is attached. I have therefore planned and adopted the following method:—

The four arms, S O, J K, L H, and N *p* are made as in fig. 12, Pl. 5, with two pins or rollers at the end of each of them, and which guide the motion. One of the pins is on one side of the arm and one on the other, in contrary directions, at a small distance apart as shown; and they work round two similarly curved guides fixed to the carriage, but whose curvature is *reversed*; these curves are shown in figs. 1 and 2, pl. 2, where one of them hides the other, which is also put out of sight itself by its own back, but both are dotted, to show them, and they are fixed to the carriage, so that one of them faces the other as a box does to its lid; but with a space between them for the arms which works between the two, one of the pins of the arms working in one curve and one in the other, each bearing half the pressure, and these curves are figured 1, 2, 3, 4.

It is to be well observed that a fatal error is likely to occur in the constructing of the arms with their pins or rollers or in the fixing of the curves, and which would consist in placing the pins on the wrong sides of the arms, or in fixing the curves with their wrong faces to the carriage, and parallelagrom. Thus, in fig. 12, the pins are so placed that they may work in the curves, supposing the one of which the back is seen to be next the parallelagrom, or when they are faced to each other as in the plate; and in fig. 2 they are so fixed as to suit the curves, if the back of the one which is now seen were nearest to the body, which is not shown there, but represented in the diagram fig. 2, pl. 6, and also reversed to each other; in either case, the position of the curves would not be altered by changing or turning them both together, or by fixing them end for end, but that the curves must always be reversed to each other, and that there are two ways in which it can be done, one answering to the arms fig. 11, and the other to fig. 12.

It might appear that fig. 11 and fig. 12 were similar, though with their different sides shown, but they are not: the one may be considered right-handed, and the other left-handed.

These two pins, then, regulate each other, each preventing the other from falling into a wrong part of its curve, while they work round the small ends; and during which they guide the parallelagrom right.

The remaining part of the curves, which join the ends together, only serve to guide the arms to their bearing ends, when the wheel goes on level ground, they then slide along it, but without bearing with any weight, excepting a small part of their own, and therefore do not cause much friction there; and, if well made, conduct the arms smoothly and quietly to their bearings. The shape should resemble the drawing; this part is not found by rule, but by repeated trials, which will be explained hereafter.

The curve in the diagram fig. 2, pl. 6, is placed so as to answer to the arm 11, the light shaded pin working in the dark curve, and the dark pin in the light curve.

But when any occasional impediment is presented to the feet by the inequality of the ground, then parts of the connecting curves, instead of the end curves, bear the weight, as the pins drag along them in the following manner, and then producing more friction.

Suppose, now, that the carriage is going as the hand points in the plate, and that a high obstacle should oppose the foot A, and on which it could not slip; then, as soon as the foot will touch it, the arms S O, and L H, (which till then had been guiding the motion, and pulling against their respective curves) will cease to be in contact with them, and also cease to guide them; there will now be two feet on the ground at once, and during which period not any of the arms will guide, but the feet A and D will guide each other, and continue to do so for some time, during which period the shape of the parallelagram will become somewhat different. B and D being more extended, and A and C less so; and the arms N *p* and K T will become nearly perpendicular to the curves, after having traversed part of them without bearing with weight, and after which they will no longer permit both feet to remain on the ground and guide each other, but are themselves dragged along, the remainder of the curve, bearing the whole weight of the carriage, till the obstacle is surmounted; in leaving the obstacle or depression the action is reversed. Additional *short* pins near the others on the arms to work against the outsides of the end portions of the guides to prevent the feet from being pushed back by an obstacle might be tried, but it would require for the guide to be cut away, to make room for it, and might have some other disadvantages.

The double pins in figs. 11 and 12, only act together when in the end portions of the curve, and while they are in the connecting parts only one of the two pins in the arms bears; and the arms generally keep in contact regularly with the connecting curves, but sometimes some slight occurrence, as changing the direction in which the carriage goes, renders it otherwise; as the arms which in the connecting curve stand in different positions according to the direction of the motion of the carriage, and when they are approaching the bearing ends, one of the pins works along a whole side of one of the curves, so that the *part* of the end nearest the main centre I, is always that part at which the pin enters the end, and that part of the end which is farthest from the main centre I, is always that part on which it leaves it; and when the carriage goes in a contrary direction the reverse pin works against a whole side of the reverse curve, but still entering and leaving in the same way.

Fig. 4, Pl. 7, is a more full view of the whole plan. The dotted curve 1234 shows the lower guide, and the plain curve 1234 the upper guide, the faint circles being the rollers of the dotted guide, and the strong circles those of the plain guide. The arms N P and T K are a little more horizontal than the arms L H and S O, owing to an inside rim, N G, forming a groove which *only* exists in the plain guide where the strong circles or rollers work, and which prevents the pins of the arms from ever striking the centre of the parallelogram when the motion of the carriage is reversed, and obliges the arms also to enter and leave the two end portions of the guides which are diagonally opposite, in one position, and the two others in another. But in order to do so, each arm has a little curve, O, P, H, K, which work on two little rollers in the machine near H and O, and this does it, but great judgment must be used in finding its best shape. A close inspection will show that two of the faint circles of the arms stand at some distance from the corners of the curves, where the part is cut away (see the foregoing), and thus the two other rollers are in actual contact with their respective curves, which is caused by the difference of position, owing to one of the guides only having the inside rim. It must not be concealed that there is a little defect in the guides, which is that the parts which should hold against the rollers when the machine is square, require to form a *loop* according to the curve produced by the motion, and as this form cannot be made available, the two entering and leaving points, are obliged to be cut away, and in this short portion the guidance is performed by four little rollers, *d b*, fixed on the sides of the parallelogram; and which work on two curves, *f e*, on the one side, and *g h* on the other, the *external* part of *f*, *e*, being the part adopted, and the *internal* part of *h g*, and these pressing on the little rollers the defect is made up by their guidance. The curvature is marked by sliding the foot against the ground and observing the track of the little wheels. Fig. 7, Pl. 7 shows a section of the guides, DD, with the pins or rollers, S R is the arm, crooked to protect the guide from dirt, and the back of the guide has also a projection to assist this object, as shown, Fig. 5, is a kite view, and Fig. 6, is a quadrant used to give stability to the carriage when it turns, which it does, from a perpendicular axle over the front wheel; but as the slightest bending of the frame, caused by the change of legs, &c., would throw the guides or curves out of truth, this quadrant is necessary below. The pins would act better alone than with rollers, were it not for friction, their circumference being less in the way of each other; it has, indeed, been found serviceable to file off the outsides of the pins, so as to give each other room.

In order to find the shape of the ends of the guides, Fig. 2, Pl. 6, first let the curve, 1, 16, &c., be found, which the centre of the joint describes, and which will be shown by placing a blackened board behind the joint, while the ground foot is drawn along a straight line, the same length as the span of the feet, and the axle being kept still; or it may be found by points thus:

Describe a circle in the figure, which represents the parallelogram when square, touching all the four sides; then fix the points of three needles in a right line in a flat ruler, the same distance apart as between the joints F and *u*, or F and *w* fig. 2., Pl. 2. Guide one extreme point along the top or bottom straight sides 1, 9, 16, Pl. 6, and guide the middle point in the circle; and then will the other extreme point describe the curve required; or it may be projected only with the compasses by equally dividing the top and bottom sides of the square, and by numbering them contrary ways, as in fig. 2, pl. 6. Then by fixing one compass point in each of these divisions, on each side 1, 9, 16, &c., with the span of a side of the square between the compasses, and marking with the other point a number of segments of circles near the *circle* 1, 9, 16, so that each segment gets intersected by one of the same number from the opposite side; these intersections, which are numbered in the figure to show from whence they originate, will also point out the curve sought for, and from which proceed to find the small curve, as follows:

Provide a flat ruler, the full length of the radius of the circle, 1, 9, 16; in one end of which fix the point of a needle answering to the centre of the arm, and near the other end fix two needle points, situate like the centres of the pins of the arms; and between them cut a groove pointing to the one needle point; which groove is to be caused to work and to slide on another needle, previously fixed in the centre of the circle, 1, 9, 16, while the single needle point is guided continually by the large curve near the circle 1, 9, 16, and then will the two needles points trace out two small curves, round the boundary of which must then be drawn a number of small circles, the size of the pins or rollers, so that the insides of them will show the true shape of the ends of the curves, or instead of the ruler with points, &c., a piece of transparent horn, with holes, may be found convenient.

The shape of that part of the curve which connects the two ends together being found (by repeated trial), the whole guide will be complete; and in order that they may be properly made and fixed to the body of the carriage, the following operations may be performed:—

Draw a line from 9, in the large curve on one side, to No. 9, in the similar curve on the other side (passing through the whole curve found last), and draw a perpendicular between the two same numbers, (9) of the straight side (passing through the curve); then proceed to make the guides 1, 2, 3, 4, fig. 2, pl. 2, each consisting of a rim of brass, iron, or rather of tempered steel, whose insides are curved the same, for the pins of the arms to work round them; and there must also be two solid irons (or cores) of the same curvature (as the guide) as tools to make the guides by and to fix them.

The irons and guides must also have lines across both of their faces, as directed by the drawing; and on the cores there should also be lines on the perpendicular sides or edges, which will join the lines of both faces together. These two cores must then be reversedly screwed together with great precision, so that the two lines on each small end of the irons will form one right line on the edges; then if the guides are to be fixed as in my small iron model, it will be done thus:—

Into the body of the carriage, *braze* a strong iron pillar, whose depth is above twice that of the guides, with the thickness of the arm added to it, and the shape of which will resemble that of the guides, but smaller and shorter. Cut a notch in the middle of this pillar, and at the bottom of the notch make a hole, tap this hole with a screw-tap, and in these the main axle must be fixed. Then fix one of the guides with soft solder, measuring with the compasses and straight edge (notched so as to fit the axle) from the marks in the guide of the axle, so that the axle shall be in the middle; then make a hole through the two irons, the size of the pillar, and put them over the axle and pillar, so that one of them goes into the curve which is now fixed. Then solder a flat back on the other guide, with a hole in the middle for the axle to go through, and place this guide over the fixed guide, so that it shall contain one of the cores; the other core being in the other guide. There then only remains to make two holes in the flat face of the guide which is *being* fixed into the iron pillar, to tap and to put screws into it, and the two guides must be separated to take out the cores and screwed together again empty to complete them.

Fig. 6, pl. 6, is a sketch of the width of the lengths of the guides expressed in numbers; and to find its proportions, draw a line across the centre as in the machine, and cut this with 12 equi-distant perpendiculars, drawn from the sides of the curve, and measure from the right angles of the sides; then if the *long* line be called $2\frac{1}{10}$, the following proportions for the cross lines will be nearly correct, the blank side being similar but reversed; but if the main axle be very large, the curve must be wider in the middle to let the pins pass.

No.		The length of line.
1	... ...	0
2	... ...	$\frac{2}{10}$
3	... ...	$\frac{2}{10}$
4	... ...	$\frac{2}{10}\ \frac{1}{2}$
5	... ...	$\frac{2}{10}\ \frac{3}{4}$
6	... ...	$\frac{3}{10}$
7	... ...	$\frac{3}{10}\ \frac{1}{3}$
8	... ...	$\frac{3}{10}\ \frac{1}{3}$
9	... ...	$\frac{3}{10}$
10	... ...	$\frac{3}{10}\ \frac{1}{2}$
11	... ...	$\frac{2}{10}$
12	... ...	$\frac{1}{10}\ \frac{1}{4}$
13	... ...	0

The length of the sides of the parallelogram between the two extreme centres will be $2\frac{4}{10}$.

The length of the arm from the centre of the hole to the centre of the pins, will be $1\frac{1}{10}\frac{3}{4}$.

The distance of the centres of the two pins $\frac{2}{10}$; but if the outsides of the pins are filed off to make room for each other, it will be difficult to know where the centres are, unless the measurement be taken before they be filed off, and then the diameter of the pins will be $\frac{1}{10}$.

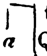
Fig. 7, pl. 6, 1, 2, 3, shows the shape of the end of the guide as it would be if the pin were in the middle of the arm instead of one side; but which plan would not do, as the pins would fall into the wrong parts.

With regard to the construction of the parallelogram, the two sides of them (*y* V and *u w*, fig. 2, pl. 5 to which the feet are not attached) have each of them three deep tubes in which axles similarly fixed in the other sides and cross pieces work. They had better have no shoulders, to rub, thus avoiding friction.

Fig. 5, pl. 3, shows the end view of the machine, the same letters and figures applying as in the other views. The arms are drawn in figs. 8 and 9, pl. 5, in two views.

Fig. 1, pl. 5, shows the wheel when square, but with a different kind of joints, to avoid friction; by *rolling* round on the bearing side *instead of sliding*, *v* shows the little axle which is triangular rounded at the back and a little so on the rolling angle for durability, (and it works in a properly curved tube, *v* G in the other side as shown. The arms work also by means of rolling angles, and require to be curved and bent as shown at figs. 5 and 6, pl. 5, one being a flat and the other an edge view. Fig. 7 shows the shape of the pin on the side. Very great precision is required as to these joints and their distances from each other, and without this they will not act at all. It is, indeed, doubtful whether the advantage will repay the great difficulty of adopting them, without further preparation. For a more particular description of which plan see the "Repertory of Arts," June, 1821.

All the foregoing plans require four wheels (at least three), but the following is one for a two wheeled carriage, as it does not require, as the others do, for the carriage to be kept level, nor does it change the point of support of the carriage even on bad ground, or if applied to a four wheeled carriage, will not cause a strain on the carriage as the former do. They have also the advantage of entirely changing their form and action, suiting the inequalities of the ground, so that in the changes of feet on unlevel ground, the carriage moves the whole length of the wheel and thus, gradually overcomes it, instead of, as in the former plans their having to overcome it, while the parallelograms are describing a small portion of their curves (from nearly square to quite square), each side being a rail laid down on two feet upon the ground in whatever form the ground may be, and upon which the carriage proceeds. It is also stronger, and its principle more within the capacity of an ordinary workman. Still, on the whole, it is much inferior to the last machine. The feet striking the ground forcibly, and thereby causing great loss of force in fast travelling, neither does it turn horizontally so well, there being generally two feet on the ground at once, and takes up more room

Figs. 1 and 2. plate 7, show this scaper in two positions; and fig. 3, is a kite view of fig. 1, the same letters applying to all three; and in fig. 3, the top rail of the carriage supposed to be removed; *a b a*, is the frame of the carriage, and A C, D F, G I, and J L are the four sides of the parallelogram, jointed at *d f h* and *k*: *b g* is a cross piece, and *e i* another; these are also jointed at *l g e* and *i*, and are bent or formed in right angles, *g*, with the sides so as to form a recess as shown at *l g*. Fig. 3; *e*, *i* being hidden in this figure, M M Q P is a standard or piece, which in a front view would appear thus 

the part *a* showing where it is attached to the frame *a a*, and Q representing an axle fastened to the other end of it, upon which a large wheel R R with *three flanges*, one being on each side, and one in the middle: so as to form two grooves; one being for the one two and the other for the other two; as two of the bars are behind the other two, S V Q is a *lever*, one end being jointed to the frame on an axle at V, and the other end to the centre of the parallelogram, with a long tube V at one end and another tube Q in the other; one working on the axle at the frame at V, and the other at the outside of a tube Q in the cross piece *g l*; the other cross piece *e i*, in this machine, having an axle which goes in a tube in the cross piece *q l*, this lever allows the *centre* of the parallelogram to rise and fall without the carriage. T T is a spring to assist the scaper to change its position from that of fig. 2, to that of fig. 1, the spring being shown in the other side, for another scaper without the lever S Q, but requiring as in a subsequent plan, which will be hereafter described, a *regulator.* And as the tube Q must work past the frame *a a*, the frame must have an opening in it, to allow the axle Q to pass, unless the scaper should be fixed further from the frame, or the tube Q made shorter. The action then of the machine is thus: The wheel R R, which is fixed to the carriage, runs along the sides G I, while the two feet I G fig. 1, remain stationary on the ground at the same time, and till the scaper has nearly acquired the form of fig. 2, when foot F relieves foot G, soon after which another foot, D, comes down to act in the same manner with foot F as foot G had done with foot I, while the carriage proceeds contrary to the way of the arrow; or if the action be reversed, then will the arrow point right, the centre of the parallelogram rising and falling as the carriage goes. Now suppose an obstacle, x, should be under the foot I, fig. 2, the foot will then stop upon it, an act with foot G the same as before, excepting that the wheel R, and carriage *a a*, will have to travel up an incline plane; which the side, *I*, *G*, will then form instead of a horizontal plane; and the joints *g*, *f*, *e*, *d*, *l*, of the feet on the ground will describe a different curve to what they do on level ground. This machine, in fact, lays its own railway, and rolls over it whatever be the nature of the ground.

As two feet bear at once, the joints require freedom to yield in turning a corner, the axles and boxes are therefore conical reversed. E L C is the axle and box, B A, F G are two screws which work in a notch to keep the axle and box together, D I H is part of the axle. (This fig. is drawn too long.) The feet in this plan should not be so high from the ground as the drawing, the outsides of the feet (when high) being in the way of obstacles. Great strength is required in the cross pieces and lever, and they are therefore made of iron plate, hollow and soldered together by corner pieces, great care must also be taken that both wheels stand parallel to each other.

The wood cut, figs. 1 and 2, pl. 8, shows this plan in a better form, applied to a cart, and provided with the regulator N. Here is exhibited the machine in the two extreme positions, and fig. 3, is kite view of figs, 1 and 2, the same letters applying to all three. U U is the frame, and A C, D F, G I, are the four bars jointed at A C G and I, K E and B H jointed at B H E and K, and turned square at the ends, as at A C, fig 3, to admit the wheel R, bar G I being hidden in this view; X X is an iron which holds the axle of wheel, R, S M Q is the lever, and V and Q the tubes; T T is the spring of steel which raises the weight, not in leaves as that causes friction, but made taper in width but not so in thickness. In order, then, to adjust this spring to its exact strength it is held in an iron, *a*, which has an axis above upon which it can be turned more or less. Behind this is another iron, *b*, through which goes a screw, S (with a counter nut), and which by screwing more or less, tightens or loosens the spring. But as the action of the spring itself is too irregular, the regulator alluded to before has been adopted. The lever has a grooved roller, *d*, and the spring another, *e*, underneath the former, between which goes the regulator, this being an iron, N, peculiarly curved, and turning about a centre *(Z)* at *only a short* distance off, keeping the spring and the lever apart, and turning about its axis as the lever and spring work, so that these two rollers press against it, where they meet with a considerable change of figure of the regulator, which is so shaped by repeated trials as to cause the spring and the lever to approach each other as the spring bends, and thus lessens its otherwise increasing force; its controul is perfect, and it might even be so formed as to reverse the power of the spring (*viz*:—the less resisting the more bent) its advantages, indeed, do not appear confined to this use, but to springs generally, and particularly to those of common carriages, by which a degree of elasticity could be given to them far superior to the present mode, some modification, however, would be required to prevent their being too susceptible of difference of loads.

A more simple plan (Figs. 1 and 2, Pl. 8) for a two (or a four) wheeled carriage has since occurred to me ; this is more properly an appendage to a wheel than a substitute. It consists merely of eight bars A A, (more or less,) with feet jointed and halved together so as to be equal in thickness, and forming a polygon to envelope the wheel which rolls within, each foot taking the bearing in turn, the polygon changing its shape as it goes (as in figs. 1 and 2) : and this must therefore be *larger* than just to contain the wheel, which must have two deep rims to keep the polygon on it, or the bars must have them instead so as not to rub the ground. The objections to this plan are, the noise it works with, and looseness of the parts, and that it has eight bearings instead of four ; but its simplicity is in its favour, and it might be varied by having two wheels in the chain instead of one. (See the Register of Arts, vol. 6, No. 100, for a full description of these plans.)

The last plan I have to describe, is similar to the one, Figs. 1 and 2, Pl. 5, excepting that instead of being guided by arms and guides, it is governed simply by a curve pressing against the small wheels on the joints. It is not equal to that plan in the avoidance of friction, but is much stronger and much easier made. Indeed, this seems the plan most likely to be at present available, and is shown with an omnibus attached.

A, B, C, D, Pl. 8, is the parallelogram with four feet, the bottoms of which are smaller, but longer than in the former plan, and the shape is not confined to being a circle about the joint as in that plan, as here the curve is adapted to the motion and shape of the feet, each side having only one foot, the others none, (as before) *e g* and *f h* are the cross pieces ; and all the joints should consist of long tubes and axles, so as to prevent play and friction. In this plan, as in plan Pl. 5, there is only one foot at once kept on the ground. W U V Y, are the wheels which in turn work under the iron curve K K, this forms a continued rail-road which runs on the wheels, and being curved so as to travel in a right line without rising and falling. The shape of this curve is found as before by a leaden wheel, and when traced, it should be carefully cut out and tried in the same situation on the board, to see that the curve touches the wheels in every part of the movement.

This machine works with great facility and quietness, and turns well, but will not do for a two wheeled carriage ; as there is only one foot down at once, which would cause the carriage to tilt before and behind as the feet changed their positions. Neither does this machine act so well as plans in Pl. 7, when great irregularities of ground exist, as here the irregularity must be overcome while the rollers are coming to their level bearing, instead of having a whole side's length to do it in.

In order, for this machine to turn horizontally, the frame L L is divided at P, one side being fixed, and the other turning about its centre S, and is provided with an arc of a circle at top and bottom, about the centre I ; the other half having a sheath similarly formed for it to slide in. Another drawing is required to show this complete.

It were much to be wished that this plan and similar ones could unite the advantage of the two wheeled ones in Pl. 7, of adapting the shape of the parallelograms to the inequalities of the ground as they do : this cannot be expected, but the following invention in a degree accomplishes that object, thereby rendering the action much more smooth and complete than without this addition.

In order then to reduce the jerks produced by uneven ground, the curve K K, Fig 2, Pl. 9, is contrived to give way and rise up on the one side over the foot where the prominence may lie, or the reverse if a depression, and recover itself as soon as overcome by the following means.

Fig. 2, shows the back of the curve K, K, M, with the parallelogram in the position it stands when the foot D has come to an obstacle: part of this curve being shaded dark, and the other part shown by a faint line, because it is hidden by a board A H, which goes over it; the foot D, having come to the obstacle shown, raises the curve from the common position fig. 1, K M K, to the one of fig. 2; and as soon as that foot arrives at the other end of the curve, the curve returns to its common position, by which means it is evident that the obstacle will be gradually overcome, instead of rather abruptly as in the old machine; and this is done as follows:—

Behind the curve K M K, is a board E F L H, made fast to the carriage *b*, fig. 1. In this board there are four grooves or slots E F G and H, Figs. 1 and 2; and each of which slot has one part H or G parallel to the ground, the other part shown at the back by E Y and F Z, fig. 2 being inclined upwards. Each angle formed by the two portions of these slots, contains a roller shown at fig. 4, Y Z L, which revolves on an axle fixed in the body of the curve K M K, so that when the ground is level, the angular corner formed by the two portions of these slots bear immediately on the rollers; but when an eminence is in the way of the foot which is coming down, this foot presses or resists endwise against the curve, and pushes the curve (in which the main axle of the machine is fixed)—backwards by which that portion rises up by means of the elevated part of the slots which the roller will then traverse; while the opposite end of the curve keeps the same height as it was by means of the horizontal parts of the slots which the rollers on that side then enter; and when the wheel of this foot arrives at the other end of the curve, the curve will no longer be forced out of its natural position, so that it can easily be pushed back again, and which is done by *a worm spring* V U, on each side of the curve, Figs. 1 and *b*, which springs are attached by one end to the back board E F G H, shaded light; and the other to small projections on the front board, shaded dark, shown in fig. 5, S*d*., in the kite view of the machine, the same letters referring to the same parts; so that after these two boards have slidden against each other, the spring on the one side or the other pulls them into their places again when the obstruction is gone. These springs, however, are not merely attached to the two boards, but must be drawn to a certain tension before they begin to act, and not only this, but must remain so stretched when not in action without at such time causing any tendency to move the two boards, or to act on each other; without which precaution the curve would be unsteady, and would yield to the slightest force when it ought to be fixed; so that the curve would then come out of its proper position on level ground: and this is accomplished by stretching each spring to a certain point of its own *board*, and then keeping them thus fixed on their respective boards *to* a small catch in the same board without any communication with the other. Each spring has then a sort of chain, *m*, *n*, *q*, fig. 5, composed of three flat links, (or perhaps two might suffice) and this chain connects the spring of the one board to the projection of the other, and at the first link between *n* and *q* there is a correspondending projection to hold against the board it belongs to, and serves to hold the spring ready stretched before the action takes place; but the moment the curve rises up, these two catches are thereby relieved from each other by another catch on the other board, so placed as to pull the string still further, and only then will the spring influence the other board.

Some difficulty may probably exist in perceiving the action of these springs; but it needs only being borne in mind that each spring is constantly kept on the stretch on one board, and has no influence on the other till an attempt is made to remove them; but when the spring on the one side, V or U, figs. 3 and 5, is pulled away from the catch, it acts on the other board to draw it back in its place, during which time the links of the chain of the other spring, U or V, fold over each other, as in R, fig. 5, and allow the action of the opposite one, without being affected by it. Figs. 1 and 3 show the spring when not in action on the other board, and fig. 5 shows it when it has been drawn a little out of its natural position by the other board.

In order to reduce the side friction, small rollers might be introduced edgewise between the two boards. An improvement might also be accomplished by letting the bottoms of the feet come immediately under the little wheels, as shown at C and D, fig. 2, instead of being behind them, but which requires an end view, and by having a small bar connecting the axles of the small wheels to the foot, by which means great strength would be acquired in the feet.

There is still one small imperfection in the action of the feet, by having them on alternate sides; as it causes a slight dragging on the ground at the instant of change. How far this might be remedied by letting each side have its own feet remains to be tried; but this would require a different curve for each couple of wheels, unless the shapes of the feet themselves could be made so as to make up for the difference of curvature required for the different feet.

The small figure (fig. 4, pl. 8), resembling a horse-shoe, is a substitute for a nut to the axles of this machine or others; they are of tempered steel, so as to spring; and in the end of *the axle* there is a groove, into which this shoe is forced, which then closes and keeps on the wheel. The guiding curves in this plan and in figs 1 and 2 Pl. 4 are conchoids, or nearly so.

Very great accuracy is required in all these machines, and without which they will end in total disappointment; but when well made they work with the greatest ease, freedom, regularity, and quietness.

SUGGESTION OF A MODE OF ESCAPING LARGE OBSTACLES WITH COMMON WHEELS (but untried).

It is possible to escape large obstacles with common wheels to a certain extent thus: (by the following *untried* plan).

Figs. 12 and 13, pl. 13, are the body, to which four small wheels are attached, H and G being the two seen. They bear on a flat curved platform A B, slightly depressed in the middle C. The ends A and B being elevated and to this platform the carriage wheels E F are attached, which run on the ground K L. And D is an obstacle met by wheel E, which will raise that end of the platform and cause the body to roll back relatively to the platform towards B, and so that the wheel E will get over the obstacle without the weight, and when this has been done the body will recover its usual position. If a depression of ground be in the way the action will be reversed. The platform would be more perfect if straight, but then the body would not so well recover its position. Another method might be by subtituting a pole erected from the centre of the carriage to hang the body on, instead of the platform, but in either case the body would no doubt vibrate a little before it settled its position after the impediment were passed.

Fig. 4, pl. 6, is a velocipede, with a hand-motion to assist the feet of the rider. It has a circular rack, D G, which works in a pinion, E, in the front wheel, and has a ratchet, so that in the back motion of the handle, C, it gives way. B is the rest, which comes under the arms of the rider instead of his elbows, so that his hands are free to act, and H is the saddle. He then, by working the handle, adds to the propulsion of the vehicle.

ANTI-COLLISION RAILWAY CARRIAGES.

The machines I have now to describe are railroad carriages which avoid collision. When these carriages meet or overtake each other, instead of running foul together, and destroying life, limb, and property, the one turns the other out of its course, and they then quietly pass side by side, on the common part of the road, though without the power to regain the rail without help.

Fig. 1, pl. 10, is the first carriage of one train, and on which carriage the body for the passengers, &c., is to be placed; each wheel of which, A B C D (figs. 1 and 4), is in a separate frame, shown at fig. 3; each of which frames has a long axle above the top of the wheel, perpendicular to the ground, which axles work in sockets, E F G and H, figs. 1 and 4. K, fig. 3, in the bed of the carriage, so that the wheels can turn horizontally, as shown in the bird's eye view, fig. 4; each socket having also a small pin, L, fig. 3, parallel to the large one, I, near to the latter, and the small pins being so placed, that those of the wheels C and D stand outside of the carriage, while those of the wheels A and B stand on the inside; so that all the frames may be turned at once in the same direction; and in order for them to do so, there is a plate R with four holes in it, which goes on all the small axles, and attaches them all together, so that no one frame can move without moving the other three in the same direction. M N, figs. 1 and 4, is a curved lever or guide, affixed to *one* of the frames of the wheels, so that any pressure against it will cause this frame to turn all the others.

Two of the wheels on one side, are grooved so as to work on the rail, but the other two wheels are *not* grooved, and the rail on which the latter two run, is not meant to be raised above the ground; or if the rail is already made, the earth must be raised up to the top, so that this rail does not project. The grooves are a little smaller at the bottom than at the top; by which means, when the wheels are horizontally turned, they rise off the rail. Figs 1 and 5 is the carriage of the opposite train, and on the side, a horizontal wheel, F, projects, which striking the guide of the other carriage, the guide with the four frames holding the wheels causes them to go off the rail at once, but remaining undisturbed upon the rail itself, (having no horizontal action). The hind part, N, of the guide, is bent the contrary way, so that after the carriage has been conducted off the rail, the horizontal wheel presses against the guide and turns the wheels back again, causing the two carriages to pass side by side; and in order to keep the wheels steady after the carriages have passed, there is a slight spring, O, figs. 1 and 4, on the carriage, which presses against one side of the frame of any one wheel, and this of itself tends to turn and keep the wheels in their right course.

A model exactly on this plan has been exhibited which acts precisely in the way described, how far this may succeed in practice where great power and velocity are there, remains to be tried.

It might probably be preferred for the four wheels to be alike with one flanch, as in fig. 7. The rails must then be filled up with earth between them; as in the latter plan, as well as in the former, it would not, by any means do for the wheels which have been raised off the one rail to come against the other, as this might upset the carriage.

It appears that not only a single carriage can be thus acted on but *a whole train*, as it is presumed, that the foremost carriage would be attached by means of their levers &c., to the others so as to turn them off the rail when it is itself off this usual right line; the details of which plan however have not been tried. The hind carriages of the train as well as the fore ones might be thus equipped and this would operate when one carriage overtook another, the twisting motion of the wheels when struck by this guide might cause some difficulty as to the action of the steam engine upon them; but this does not seem difficult to overcome. Two sets of railroads would as in the common plan be best, but it seems possible to dispense with one line of them, as the trains turn off the rail when required to pass each other.

PLAN TO LESSEN THE FRICTION OF RAILWAY CARRIAGES.

In order to lessen the friction of railway carriages the flanges of the wheels which rub against the sides of the rail are omitted, and a horizontal wheel or roller B, Fig. 3, plate 10, is attached to each side of the bottom of the carriage, which roll against the sides of the rail instead of sliding.

If the rails were made suitably, the roller B might have a flange (as shown by the faint line) to come under the rail, but not touching it excepting by accident, and this would prevent the possibility of the wheels being thrown off the rails; but this addition is not compulsory.

Since this had appeared a gentleman has applied horizontal wheels for this purpose, but has an additional rail, though without noticing, my priority as to this plan.

ECONOMICAL RAILROAD.

A railroad, fig. 14, pl. 13, may be made with less than half the iron at present used, when economy is the chief object, by laying it down in alternate rails and vacancies; that is to say, a yard of iron G, then a yard of nothing H, then another of iron I, and another of nothing K; the carriage then must have five wheels, A B C D E, more or less in a line, rather closer together than the length of the rails. By which means they can never fall into the hollows, because before one wheel will have arrived at the hollow another wheel will be on the rail and keep it up.

PLAN TO INCREASE THE BITE OF RAILWAY WHEELS IN STEEP GRADIENTS.

In order to give railway engine wheels a firmer hold in up hill work, without interfering with the action in levels, I propose for them to have two very strong angular V flanges, but leaving a flat bottom, and when the rail is up hill it must be a little thicker than in the other parts, and a little angular, so as to fit the flanges, and so that the bottom of the wheels shall not then touch the rail, but resting by means of the two flanges squeezing the rail, and thus causing a great resistance to its slipping without much increasing the rolling friction; but the moment the level is presented, the rail being thinner in that place, the wheel would then run as usual without increased friction.

IMPROVEMENT IN THE TURNING OF CARRIAGES.

Fig. 2, pl. 11, is a mode of fixing the front wheels of carriages so that they shall both turn horizontally over their own centres, instead of by means of one axle between them. There are two objects gained by this, the first being that it prevents the shaft or pole horses from being jarred sidewise by obstacles opposed to either wheel, which in heavy draught is very distressing to the horses on rough ground. The other object is that it prevents overturning of the vehicle, as however much the wheels may turn the points of support in front do not contract as in the common plan. *a a, f d e b c* is a jointed frame or parallelogram and the piece, a a, is a fixture at right angles with the perch *i*. The dotted lines *g, h, e* with the piece *a a* show the mechanism when the carriage is going straight forward and the dark part when turning. It being evident, that as the piece *a a* cannot turn about the centre K, no obstacle could twist it round as in the common plan. Mr. Ackerman, some years before, had the merit of a nearly similar invention but his object it appears was against *upsetting* and to have *large front wheels.* He placed his wheels beyond the centres (side wise) instead of directly underneath, and thereby in a degree annulled the advantage he may not have been aware it would have possessed.

PLAN TO PREVENT HORSES FROM FALLING.

It appears that all shaft or pole horses of four wheeled carriages might be entirely prevented from falling by having the shaft or pole strong enough to support the horses, to be attached to it by means of a flat (covered) iron band under their bodies, which would render falling impossible. Two wheeled *carriages* would require props to the shaft nearly to touch the ground. A very ingenious invention of George R. Peppercorne, Esq. has appeared, consisting of a sort of carriage on which the horse could support its own weight, being in fact a velocipede for a horse, and on which it rested, so as to *assist its motion, reduce the labour,* *and prevent it from falling.*

MANUMOTIVE CARRIAGE PROPELLED BY THE RIDER.

Many have been the inventions of carriages to travel by the exertions of the rider without horses or steam, some worked by the hands, some by the feet, and some by both together; which latter is best if it can be well done, especially one invented by Mr. Hancock, if it could be guided. Most of these machines also by other authors have difficulties as to turning, because in turning, the wheels on the one side must turn faster or more than those of the other, so that two of them on one side cannot advantageously be turned by one crank or by one motion of the limbs. Fig. 1, pl. 11, exhibits *my* plan, in which the carriage moves with facility on a good road, but requires considerable practice to use, though less than the crank ones do. Its speed seems about eight miles per hour, on a good road. It is worked simply by the arms, but which are assisted by the motion of the body, by which the action of the large femoral muscles come also into action, considerable additional power thereby being obtained. The success of such machines is greatly to be wished, as it would not only relieve horses from much labour, but would afford a healthful athletic and delightful exercise to many persons who prefer such independent modes of transit, free of expense, to being imprisoned in listless inactivity in a carriage, when free from fatigue. And though such machines go well on a common good road, it must be borne in mind that on flat pavement or on rails they would go with great speed with little labour and thus form a good substitute for horse and steam power.

This plate is on the scale of an inch to a foot. It has two large wheels, A B and D E, in front, and two small wheels U and W behind, but since the drawing has been made, it has been found necessary to raise the seat and also to bring it rather nearer to the front than in the plate. P is the floor of the carriage, and O and I are two upright pillars strengthened by two angular stays Q and Q. The front wheels are held by the pillars O O O O, shewn in a side view in fig. 2, A B C being an end view of the front wheel, which as well as its fellow has a small wheel on the nave with a taper groove for a band, or what would be far preferable, a set of teeth to fit into a toothed chain band, and on the top of the pillars are two similar wheels F and G to receive the top of the band, and the latter wheels have each a handle by which they are turned; and this turns the carriage wheels. The three elbows O O O in the pillars fig. 2, must be to a nicety, so as to leave room for the carriage wheels, for the wheels F G and also for the handles and hands of the rider. Near P, fig. 1, is a strengthening iron fixed to the crooked iron *d* at the bottom of the pillar, the other end being attached to the carriage floor; and Z is the seat. The hind wheels, U and W, are placed on the cross piece, Y, which does not, as in a common carriage turn about the middle, but is a fixture; each end of it having a perpendicular axle, on which works a tube or box attached to the nave of each hind wheel, the nearer to the nave the better, or if the hind wheels be dished *inwards* into a kind of recess, the tubes can probably be placed directly over the peripheries. By this means the obstacles of the road do not tend to throw the wheels out of their course, and the carriage is secured from upsetting. In order for these wheels to be guided by the rider there are two rods X and Y, fig. 1, which are jointed on a projecting piece attached to the tubes, the other ends of these rods *a b*, being jointed to a foot-board T S, which turns horizontally on a long perpendicular axle V. The rider, then, placing his feet against this board, can turn it either way with ease, so as to guide the hind wheels, which act as a rudder. The heels of the rider may either rest on the carriage floor, while his feet move on the ancle joints, or, rather, the board may have a *ridge* for the heels to *rest on*, so that the legs move instead of the ancle joints. But as in turning a corner one wheel must unavoidably revolve more than the other, the relative positions of the handles would become dissimilar were the handles affixed immoveably on square axles. They therefore have *round* centre holes which work on *round* axles of the wheels; and in order that the handles may turn the wheels, the wheels have a number of long taper holes on their faces in a flat iron ring, the *length* of these holes being concentric with the centre of the pulley wheel, and the handles have a pin made as in fig. 4, which can be placed in any hole, and there fix the handles in any position. These handles have a swell at the back, as in fig. 5, but being straight the other way, so that while they can be turned in and out of the holes they are still steady. Willow is the wood I prefer for these machines; but well painted to prevent the attacks of worms and wet. A better plan for the handles has, however, since suggested itself to me, preventing the liability of slipping out of the holes H pl. 14 is the band, *f g*, figs. 3 and 4 are the puller wheel, and *e*, *b*, *a*, the arm; and the handle, *b* is a lever working on an axis on a projection C, on the arm, the one end of which has a stout pin that goes through a hole *d* in the arm, and of a length to sink into the holes in the face of the pulley wheel, so as to fix the arm to it in any position, according to which hole it be dropped into, and when withdrawn sets it free. *a* is the handle, and at the end of it, near the arm, there is an iron ring with a circular thin projection which is embraced by a notch in the lever *b* admitting the handle to turn round alone, which being a little shorter than the axle of the arm, it can slip to and fro, and thus move the lever *b*, and draw the pin in and out of the holes by the pressure of the hand, and *e d*, is a slight spring to assist the hand in keeping the pin in the holes At the other end of the handles is a little flat plate (not stiff, but free to turn) to rest the thumb on and this keeps it steady.

Another plan has also appeared to me; but which I think is not probably so good. This is by having a double ratchet on the pulley wheel g. figs 3 and 4; one being on each side of it, and the notches made so that a catch (which is in the arm) can, by twisting the handle, hold each side of the wheel fast, or let it be free, according to whether the catch be in the notch or not, and the arm is contrived so as to offer two catches; the one on the one side turning itself into the notches on the one side of the wheel, and the one on the other into the other side, the one being out when the other is in. In order to allow this action the arm B is in two pieces, as if cut in two in the middle, and the one half has a pin which works in a tube in the other half, and thus allows it to turn longitudinally, and the arm may be lengthened out beyond the centre of the wheel to rest on the opposite side, and thus prevent too much play of the handle. The half next the handle has the two catches, one on each face, but on the same side of the handle, or in other words the two catches meet each other like two jaws on one side of the arm, and C and d are two broad shoulders to rest against each other, or if preferred, the notches may be in two rows on the same face, but in that case cut right and left, still I prefer the former. The action is thus :—When wanted to hold fast in one direction, the handle is slightly twisted round by the hand and this fixes the catch in the notch, and when wanted to set it free the handle is kept in the same twist, but pressed in an opposite direction, so that then the carriage may also go contrary without disturbing the handle, and the same applies to the other side; the notches on the one side being for progression, and on the other side for retrogression.

The action of this locomotive is that of a windlass, and I hope it will prove to surpass in power those on other plans. The rider however, is obliged to sit instead of stand (in order not to be thrown forward by obstacles) which may detract something from the force, yet is the action one of great power.

The mode of turning corners by the action of the feet is, however, not a perfect one, as while the hands are pushing the feet lose their control, and the machine is apt to go at random, yet great practice might probably obviate this evil. In order however to obtain more control, the foot motion for turning corners has in the following plan been dispensed with, and the front wheels made to turn horizontally instead; by means of the handles alone. Here the two wheels, B and D, fig. 2, p. 11 turn in their frames O O by means of two hinges *g g* attached to the pillars, also marked *g g*, and they are shown in their *turned* position. But this does not prevent the evil of the one wheel turning faster than the other in turning a corner. Z is the seat, G F the pulley wheels of the handles, and *c d* those of the carriage wheels, the former being the same size as before, about 8½ inches in diameter, and those on the carriage wheels about 6¾, the carriage wheels being 30½, and the radius of the handle 12 inches. But it would be best to have two grooves, the one for quick, the other for slow motion in the top wheels, and reversed in the bottom ones, so that the same band could be shifted, the grooves must be v shaped or angular, so that the band does not touch the bottom, or they may be in a *zig zag*, which plans prevent the bands from slipping. T is the foot board and H H the rider's feet, *d d* are strengthening irons, and the frames O O (as in the last machine) are of wood coated with iron, as they must be light and of great strength. These two pillars with the wheels, must always turn exactly alike, and they, therefore, have a rod jointed to each pillar *a f b*, and shown at fig 2: *c c* and *e e* being the frames (marked *g g* in fig 1.) The *hinges* between the frame and the pillar *c* and *e* being visible, and P being the carriage floor.

This plan of guidance is more simple than the former, and answers well excepting when the handles are quite upwards, in which position the wrists are not well able to guide. But for two persons to work, and each having both hands on one handle this evil might not exist.

A third plan of guidance, fig 19, pl 13 is to have a pivot or axis T, between the two front wheels, and a bar under the floor of the carriage, with a tube to work upon it; at the end of this bar is a cross-piece or L, to which the hind wheels are attached, this cross-piece having friction rollers between it and the bottom, and the whole front of the machine with the rider turns about the pivot, when one handle is worked harder than the other; like with oars, and do without a rudder. For a right handed person the pivot had better be about an inch nearer to the right side than the left, to favour the left hand.

In the plate *a b* shows the bottom of the carriage topsiturvy, T S is the floor, and B D the front wheels, U and W the hind wheels. T H is the bar with a cross-piece at the end, on which the wheels U and W are placed. K L is an arc of a circle about I coated with iron; this supports the bar as it turns, and a similar piece is placed below this piece, (when not topsiturvy) to keep up the bar if the hind part of the carriage should require to be lifted up. The cross part of the bar works between these two arcs, bearing against the friction rollers. By this method the carriage turns easily, but it throws the chief stress in turning on the one hand, or even requires for the other hand to press back. It also refuses short turns, and has some difficulty when required to move the carriage a little latterly out of its track in a short distance, and then keeping in a course parallel to the former. The dotted lines show the position when turning. I have, however, in contemplation the following modification of this plan. Here the wheels U and W, fig 18, pl 13, do not move latterly out of their place, but turn horizontally as nearly as possible to their own centres, and instead of being attached to the cross-piece of the bar are attached to the body of the carriage. T H is the cross-piece, to the ends of which are jointed two rods P S and Y R, and the holes in the cross-piece through which the axis of the other pieces work must not be round but long, to give freedom, these rods being also jointed horizontally to the carriage; and the axles for the hind wheels being fixed therein, so that when the rods are turned the wheels are also turned. The plain lines in the figure show the plan when the carriage is not turning, and the dotted lines when it is.

This plan might also be varied as in fig 20. Here T X is the cross-piece, which has two fixed sides P and Q, into which the wheels U and W are fixed. This bar is jointed near X to the body of the carriage, and has another joint in itself in some part of its length with a long hole, so as to yield. The plain lines show it when it is not turning, and the dotted lines when it is. I do not think this way so good as the former.

Numerous as have been the plans of locomotives moved by human power the desideratum still lies in obscurity, namely, the choosing of the best mode of action. The common ones which work by the feet on two cranks, effect a good speed on good roads, but are defective in turning, and as the arms of the rider are unemployed in progression, the full power of the person can come into play. The same objection lies, and in a greater degree to those machines which work by alternate motion of the hands while the body is kept still. In my machine the hands are in action and the feet at rest, but as the body is also in action the thighs, producing the motion of the body, may be said to furnish this part of the power.

It may appear easy to contrive a mode of action which shall bring the rider's full strength to bear, but this is a point which few have dwelt on, and is a subject so little understood by many persons, that in performing some sorts of work they do not know whether they exert their arms or their legs, or where the acting muscles are situated; for instance, in drawing a carriage by the hands they think it is their arms that do the work, instead of their legs. When a quadruped exerts itself, all its limbs come readily into separate action, but with man it is different. In most exercises he chiefly uses only two limbs, but in most species of hard work for the arms, the lower limbs add their power, such as in windlass turning, pumping, pit sawing, hammering, &c., in all of which the body is moved by the action of the muscles of the lower limbs. This mode of adding to the power, however, is not precisely the same as when the limbs act independently. If a man pulls down a pump handle from as high as he can reach, to as low, his body will rise and stoop, accordingly.the muscles of the thighs then add their force, but the pressure this occasions to those of the arms rather interferes with their motion, and though it may not cause any loss of power, it causes a longer leverage to act on, or a quicker motion necessary. The action of a man in working a long pump-handle is like the action of a long worm-spring, and the action of working by a short stroke, keeping the body still, is similar to that of a short spring. If we have a worm spring one foot long, and another two feet long, the long spring will have double the force of the short one, the same as two short springs side by side, but it will not be able to bear so great a weight, and in order for it to do so it must act on a longer lever; still it appears not to matter whether a worm spring be long and slender, or short and thick, provided the leverage be adapted accordingly. Just so it is with the human body, the arms, body, and legs, contracting together, like a long spring, with as much effect as if the limbs acted side by side, but with the difference that in the long motion there is more motion in the body itself than in the short one, and on this account it seems desirable in these locomotives to let all the limbs act independently of each other if possible; and the following is one of the untried plans, fig 23, pl 13, which probably may be found to accomplish this, but which is only applicable when there are *two* persons to work, one to each wheel; so as not to be disturbed in the action in turning, (owing to one wheel then going faster than the other.) In this machine two persons sit abreast, with their backs to the large driving wheels. This machine may be considered as in two halves, and the description of the one applies also to the other. They each hold levers d d which are connected to two cranks, formed at right angles to each other, (not opposite) and which are fixed in the hind wheels. C C being rods which connect the cranks to the levers, which perform a double office, the lower end being a foot board and the top part a handle, the hands and feet pulling and pushing against each other, and both contributing their strength. This machine must turn by the plan of figs 18, 19, or 20, simply by one person turning harder than the other, and the two persons being unconnected, will not have their motions disturbed by the one side going faster than the other. as when one person works both sides.

A very simple and powerful mode of action for a locomotive *for two persons* would, it appears, be by simply having one deep crank on each driving wheel, and a rod attached thereto, to the hands of the riders, who, by merely pulling and pushing of the rods as the cranks turn, would give the necessary action. This mode of giving motion having been applied to turning laths and found of great power, and can either be adopted sitting or standing.

The common locomotives act by means of two cranks, which work on one shaft, attached to two wheels, which causes a difficulty in turning, as then one wheel must turn more than the other, sometimes the crank is made only to act on one wheel, but then the wheel is apt to slip round, and even if each treadle could work in each wheel the action of the feet would become irregular. The hands are unemployed in progression, but are engaged in turning. Mr. Hancock's four-crank motion, two for the hands and two for the feet, is of greater power, but no provision for one rider seems to exist in it for turning. A clever plan has been exhibited of a machine which is worked by handles horizontally, and performed well on a good road, but the hands did not seem to be assisted by the action of the body.

WATER LOCOMOTION. A NEW SHAPE OF VESSELS.

The speed of vessels in the water is, as is well known, governed by a very different and almost contrary law to that of carriages on land; the latter increasing in velocity more in proportion to the power applied, while that of vessels does so much less; the resistance of the water increasing as the squares of the velocity, so that if 1 lb. be required to draw a vessel one mile per hour, 4 lb. will be required to draw it two miles per hour, 16 lb. to draw it 4 miles per hour, and 256 lb. to draw it 8 miles per hour. This renders water carriage much more fit for heavy weights with a small velocity than land carriage, but very inferior for great speed. Still by a proper adaptation of the shapes of vessels this evil can, it appears, be greatly compensated. The chief impediment to vessels, where there is no tide, stream, or wind, is in displacing the water, and it follows from this that it is chiefly the breadth and depth of the vessel, and scarcely at all its length, which causes the resistance, so that a vessel 1000 feet long would move with nearly the same ease, as far as resistance of the water (which is the chief impediment) is concerned, as one of only one foot long; and indeed the long vessels might be shaped as to be moved with a much smaller force than the short one, which would only be 1000th part of its weight; because it could be made of a more acute angle to meet the water, and the force required to displace a given quantity of water being governed by the shape of the vessel.

There follows from this, two great advantages in long vessels: the first being that we have larger vessels moved by the same power, and the offering of the means of sharpening the prow, and this decreasing the resistance to less than that of the short vessel.

It may appear absurd to think that a long vessel does not displace more water than a short one; but only let it be borne in mind that every vessel during its voyage displaces exactly as much water as is measured by the length of the voyage and the breadth and depth of the vessel. So that if the vessel be one yard wide and one yard deep, whatever be its length, in travelling 1000 yards it will have made a furrow 1000 yards long and one yard broad. All this water, then, will have been forced out of its place, while the cavity is filled up by the incumbent fluid; the ease of which operation of which is governed by the form of the vessel, so that the water gets transposed from the head to the stern, with as little swell or rising of water as possible; and this depends on the acuteness of the prow, which, however acute will force the fluid into a hill before it, according to the velocity of the vessel.

It follows then, that if a steam vessel were ten times its usual length, a smaller engine, even, might give it equal speed to that of the present vessels; and if the steam engine were large in proportion, so that very great speed might be obtained,—then would the geometrical increase of resistance be compensated for by the greater length of the vessel, and by a proportional increase of the engine.

It must, however, be confessed, that very great length of vessel might cause insecurity: but advantage might be further taken *of this principle* by constructing *several* vessels, so that *one of* *them should draw on the rest, without detriment to its own progress;* in order to effect which, let the first vessel alone have an angular prow, and the last one alone a broad concave stern, as in figs. 1 and 3, pl. 14, the intermediate vessels being oblong and fitted prow and stern against each other nearly water tight. They might then be attached together by a rope held by a man in each vessel, so that he could let it give way when required. Motion then being given by the engine to the first vessel, would if I mistake not, cause it to draw all the others in its wake: the ropes not thereby suffering much tension, if any, excepting by accidental causes; or at first starting; and even contrary to what might be supposed, the first vessel might cause the others to urge it on, without, however, increasing its speed more than the back water would do of itself, which would perform the same office were the back vessels not there.

But in estimating the resistance according to the length of the voyage, there are some other actions to be taken into account, particularly the length of the waves caused by the motion of the vessel, the consideration of which subject I will leave to more able hands; yet, with due deference to the practice of ages, it does really appear that some error generally prevails as to the proper shape for vessels. Much trouble and expense on experimenting on this subject on a grand scale it has to be feared has needlessly been lavished, when a little more attention to *theory* might have saved the whole. The present shapes it is true look well and appeared scientific, but the grounds of which it is difficult to discover. A simple, broad and flat bottom, with perpendicular sides, seems to offer much greater security against upsetting, without detriment to speed. But the shape I would submit is shown in the drawing, fig. 1, pl. 12. Here the bottom is flat, the sides perpendicular, the head of an acute angle, and the stern broad and horizontally concave, for the following reasons:—

In the motion of every vessel a resistance arises to the head by the water it displaces, and with the present shapes the force applied seems nearly all lost by this means, owing to the stern being of an angle almost as sharp as that of the head: it being evident that the head and the stern have very different work to do; the head having to cut its way with the least resistance, and the stern to offer as much resistance as possible to the water behind, and thereby forcibly propels it.

In order to try this plan on a small scale, I use *bird seed* instead of water, the motion of the water being too obscure on a small scale, and in a trough filled with bird seed, I found that when the vessel was moved forward the seed rose up in a hill (B) on each side of the head, which hills (at C) ran backward to the stern, or were overtaken by it, and then suddenly turned back against the stern (at D) as shewn in the plate, from which place it fell into the chasm the vessel caused by its progress. E, shews the back water behind these two streams, and this adds its force to theirs.

It is essential that the head does not decrease in width towards the bottom, so as to avoid becoming elevated and the stern depressed as the vessel proceeds.

After these suggestions having been made public, a strong controversy arose between several persons as to their merits *pro* and *con.* which terminated by two of the opponents to the plan having confessed their errors, as their letters in *The Mechanic's Journal,* confess in the following words:

GENTLEMEN,

"For some time I have been expecting to see in *The Mechanics' Journal* an account of Mr. Gompertz's new shaped boat from a correspondent who it appears was thus engaged. Considerable time (now two months) having elapsed since the notice to that effect appeared (in No. 18) I commenced and completed a model myself, and now send for insertion a brief account of my experiments with it, which, should they agree in their results with those of your other correspondent, will tend to settle the point to the more entire satisfaction of your readers.

After obtaining the model of a six oared cutter, 1 ft. 2 in. long, 3 in. at its greatest width, and 2 in. at its greatest depth. I constructed a model of Mr. Gompertz's newly shaped boat of the same length as the former; its width was the mean width, and its depth the mean depth of the same, and the following are the results of my experiments with them.

The weight of the boats being equalized with ballast, I found that the newly-shaped boat was much more difficult to upset than the one of the old shape, which is apparent from the fact, that a weight which, when placed on the side of the common shaped boat was sufficient to upset it, being placed in the same situation on the other, had barely any effect. When each boat was propelled forward with the same force, the boat of the new shape gained rather more than an inch on the other in the distance of a yard. In order more fully to satisfy myself as to the result of the last experiment, I performed another, having fastened a piece of twine to the head of each boat, and taken the end of one in each hand, I pulled them for the distance of several yards, and found that the twine affixed the old shaped boat was in a slight degree more tight than that attached to the new.

These experiments were several times repeated with nearly the same results, and though my mind is not perfectly satisfied that Mr. Gompertz's newly shaped boat would, when made to the full size, excel in speed other shaped boats, it is my opinion that it is well worth a trial upon a larger scale. Trusting that such will be the case.

I remain your obedient servant,
Nemo."

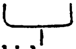
Gentlemen,—"I am exceedingly glad that your correspondent "Nemo" has put me in mind of a promise I long since made, and almost as long since have forgotten. Considering the able manner in which he has experimented upon the boats, it would seem hardly needful for me to add anything; but, however, as two witnesses are more valid than one, I send you the result of my experiments. The models are very nearly of the same dimensions as those of "Nemo," and it will be seen that the results do not differ very widely.

Mr. Gompertz's shaped boat drew only ⅜ of an inch of water, and required the weight of 12½ ounces to sink it perpendicularly, and 2 ounces (on the edge of the widest part) to upset it. In two yards it gained 1½ inches on the common one. The common boat which was of the same weight, length, width, and depth with the other, drew ⅝ of an inch of water, and was sunk by 8 ounces, and overturned by 1½ ounce weight at its mean width. Hoping that this will prove satisfactory, I remain,

Gentlemen,
Your's respectfully,
(Signed) S. K. Bland.

ROW BOATS WHICH GO FORWARD AS THE ROWERS PULL BACKWARD AND NEW ROW LOCKS.

Fig 3, Plate 12, shows a mode of causing a boat to go forward while the rowers pull backward as usual, thus enabling them to see the objects they are approaching and more easily to avoid them. For this purpose the oars are placed in the sides of the boat opposite to that at which the blade goes in the water, and are counterpoised by a weight at the end shown square, the rowers pulling *between* the row locks and the water, the rowlocks being elevated so as to let the oars clear the opposite side. For sculls or single rowers this plan may not, however answer, the shape of this boat as in the plate is similar to the other vessel.

The new rowlock is made  thus to fit the oar and turns with it on the shank which works in a tube in the boat; it prevents noise and loss of force.

AERIAL LOCOMOTION.

Aerial locomotion may be divided into two subjects, the first being the supporting and propelling an animal in the air by its own exertions mechanically, or in other words, by flying, and secondly, by the aid of chemistry by means of balloons. It differs materially from water locomotion; first, from the object being entirely immersed in air, but not so in water; secondly, from the extreme lightness of the fluid; and thirdly, from its elasticity.

With respect to the first, if no animal had ever been seen which could fly, and any mechanician had pronounced the thing possible, he would, no doubt, have been deemed almost insane, and, indeed, the supporting of the whole weight of its body on so yielding a substance as *air* by the mere strength of its wings, has in it something so different from what we are able to imitate that it seems almost supernatural; and when the rapidity and ease of the motion be considered, even with an additional heavy burden as well as the little incumbrance of the wings when not in action, and the elegance with which, in birds and beetles, they are then folded close to the body, admiration cannot fail of being most highly excited, yet so common is now the thing which is before our eyes, that the flight of a bird or an insect is by most persons passed over as scarcely worthy of a thought. Still the operations of flying has been considered by many able inquirers, though not with that attention that its interest demands, and the theories they have deduced, with due deference to the authors, seem very limited and only partially correct.

Birds are supposed to strike the air with their wings fully expanded in a direction in part perpendicular, and in part horizontal, which at once is supposed to carry them upward and forward, and that in raising the wings they contract them so as to cause only very slight resistance. Also, that in order to turn to the right or the left, they strike with the opposite wing more horizontally or with more horizontal force. The strength of the wings is thought to be necessarily immense, and that birds are much stronger than other animals, that nearly all their strength is in their wings, and their other parts very feeble.

The first part of this theory, though well conceived, seems rather so disclose a principle on which flying might probably be perform than that by which it is actually done. An attentive view of a large bird in flight will show that it does not act in this way. The wings move simply up and down perpendicularly on the shoulder-joint, and as much expanded when *returning from* the stroke as during the strke itself; still the *bird moves* forward. The necessity of getting rid of the resistance of the air in raising the wings, has led to the belief that birds contract their wings in raising them, but as *bats* and *insects* fly without the possibility of contracting their wings, it may be granted that birds may too, though the reason may not be seen, but may be owing partly to the shape of the wing and partly to the velocity of the up-stroke being less than of the down-stroke, some time being thereby lost in the stroke, but a small decrease of velocity causing a great decrease of resistance. Neither do birds appear to move one wing more horizontally in turning to the right or the left than when going straight forward, without, however, pretending to explain the whole theory of flying, the following seem to be some of the facts, though some other points may be obscure.

The wings of *all* flying animals, are, when flying, *stiff in front*, and *thin and yielding behind.* In *insects* the wings are straight, and when at rest, the stiff part is sidewise and outward, the thin side being inward ; but in flying the position is changed, so that the stiff part is in front and the thin behind. In *birds* the wings being of feathers, this mechanism would not do ; the pinions, therefore, instead of being straight from the body in flying, turn backward, so that the ends of the feathers come behind and the stiff part before, were this not necessary, the pinions would have been better straight, so that the points of the feathers came sidewise. The animal then, it appears, in order to fly forward has nothing to do but to strike downward perpendicularly, when the resistance of the air *bends the hind part of the wings a little upward,* thus forming a *wedge* against the air, and in this bent form it appears that the mere downward stroke at once raises and propells the animal, only a small force being required for progression. In turning to the right or the left it strikes harder with the opposite wing, but seemingly without altering its position, this bends still more the hind part of the wing, making a more obtuse angle with the horizon, and causes the animal to turn, but in so doing, unavoidably raises the side of its body on the side where the hard stroke had been given, as may be seen. Still a difficulty appears here as it would seem that although the bird may make a few such strokes it could not without some other action continue to do so (in flying in a circle) because each stroke would raise that side more and more till the bird were thrown on its back ; but probably the weight of the legs and the action of the tail may check this evil.

Owing to great strength being, it is admitted, required in the wings, much complication appears to have been avoided, so that the muscles of the down and upstrokes are enabled to be very large, thereby acting with great force and ease, while the other motions of the wing appear very inferior in power and action, the chief the bird has to do in flight being to move its wings simply up and down on the shoulder-joint, whether it ascends, descends, or turns to either side, still some birds have a horn on their wings with which they fight.

It is difficult for birds to rise perpendicularly, and in order to do so, as they cannot easily alter the motion of their wings, they are, it seems, obliged to counteract progression and to do this they elevate their fronts by throwing their legs forward, or by means of the tail, and the inclination then of the wings probably does this without much detriment to their ascending power, or in this instance, they may turn their wings a little down behind, the precise action in this motion being difficult to discover. The legs seem one of the instruments of changing the inclination of the body; when the bird wants to elevate its front, it, it is presumed, draws back its legs and its head, which causes the hind part of the bird to preponderate, (from the wings) and this is the attitude in which it rises. In descending the head points downward.

The legs of birds requiring to be held contracted so as to act as a balance, they would soon tire, but for a beautiful contrivance which prevents it. The skin of the legs being for this purpose made detached from the flesh, and quite loose from the body to the heel *(or tarsus)* and it is thereby able to thrust its knees more or less into this skin, which is very strong, and thus forms a kind of sling or hammock in which the legs rest in various positions with very little fatigue.

The subject of enabling mankind to fly by his muscular power alone, has long been a disideratum with philosophic mechanicians, and as long has been generally deemed impossible, and been scoffed at. Many mechanical writers of talent have advocated the futility of such attempts, yet it has been asserted that flying has been done by John Baptist Dante, and also by Degan, though no details of their means appear to be known; which throws doubts as to the truth.

The general objections held forth being, first, that the strength of birds is very great in the wings at the expense of the other parts, which are weak; and in man, particularly in the pectoral muscles (by which birdy fly) are much too small for his weight. Secondly, that all large animals are proportionately much weaker than small ones, and in proof of which it is observed that a *flea* can jump a hundred times its own length, and a large animal not five times its own; also that a *beetle* can raise an immense weight compared with its own; also that we can expect no aid from machines, as the more we increase their complexity the more is their weight.

Now, with all deference to this view, none of these *allegations seem true.* First, a man is not obliged, in order to fly, to strike by the pectoral muscles alone because birds do; but if he used only his arms for the purpose, it would be by drawing them downward (he being erect) and thus would the pectoral muscles be assisted by the broad muscles on his sides (called the *latisimus dorsi*). It is indeed doubtful whether a bird does exert such very great force, though its muscles are large, as we observe nothing very extraordinary in its vital organs, from where strength emanates, so as to produce such force; the brain in particular, (which some have gone so far as to deem a gland to secrete electricity for motive power) being small in birds; and besides this, it keeps two of its limbs idle; it also does not seem that birds and insects are weak in their other limbs as birds can run and swim, &c., with their legs and sleep on one leg, holding the other up in the skin; and flies can walk topsy-turvy (by means of suction it is said). Neither do these leaps of the flea prove its superior proportionate strength, as the length of an animal has nothing to do with the length of its leap. If an animal one inch long could leap one foot, one of 100 feet long ought *not* in order to do as much in proportion to leap 100 feet, but only to leap one, as the other had done; then every particle of each animal will have done the same, therefore would the whole animal have done so, but if it leaped 100 feet it would do 100 times as much in proportion, it being bulk or weight that we must take the proportion from, not from length. Indeed, the very reverse appears the case, as a horse can jump further and run faster as to absolute distance than a flea. Nor is the great weight moved by the beetle conclusive of its great strength, because it moves it very slowly,

But even allowing that a man is too weak to fly like a bird, there seems no reason why machinery may not as in other instances make some amends for what nature denies. It is true that the weight of the machinery is a drawback on its advantages, but that this increases *equally* with the advantages seems far from the fact, which in order to see clearly, a deeper investigation than has hitherto been bestowed on this subject is indispensable.

The question, then, first to determine is, *what force is required to support a weight in the air, by action.* The answer seems to be *the smallest power imaginable, let the weight be ever so great,* provided we employ the proper mechanism which its laws do actually present. If we support a body of lead on the air, it is not our strength which bears the chief burden, but the air itself. Still the air *can not* do it quite alone, but all it asks for is *some* assistance, however small, and having this the thing is done, provided the mechanism be right. In order to do this let us suppose a man holding a large umbrella cut in vanes over his head, it is evident then, that the larger was the umbrella, the more would it resist being pulled down, and that by twisting it round, so that the elevated sides of the vanes met the air, a force would thereby be derived tending to support the weight.

We must now imagine the air to be what it is not, namely, a material which will not give way at all downward, still yielding to the rotation of the vanes; this would cause the umbrella to support the weight from the ground by means of any slight power from the hands, which would prevent the vanes from giving way; and the less inclined the vanes, the less power would be required to prevent the umbrella from turning the wrong way, or even to turn it in opposition to the resistance; in doing which, the person would, by slight exertion screw himself up. Air, however is not such a material; it yields in every direction to the slightest impulse; the greater the velocity of any body against it, the more it resists, and in a geometrical proportion, if the umbrella were turned slowly, the resistance of the air would be too small to support much weight. Here lies the rub: but this is overcome by turning the umbrella very fast. It seems not to matter whether the air resists much or little, porvided the machine be turned with suitable velocity. If, for instance, it did not yield at all, the vanes would act like other inclined planes, screwing up the weight as much as they were inclined. If the air gave *half way*, the velocity would have to be doubled, and in proportion to the decrease of the resistance must the velocity be increased, though much less so than the density of the air might seem to demand, owing to the resistance increasing *geometrically*. The speed of the rotation would not then cause a quick drawing force on the weight, as it would do if the vanes acted against solid matter, but would chiefly be spent in constituting a *fulcrum* to act on, though exhausting by it none of the power; because whatever power may be thus expended, the reaction is on the body to be raised, while the surplus would raise it a little, and a wedge acting (slowly) on a solid substance could do no more. It follows, then, that any weight may be raised by a force, however small, acting in this way; but the greater the weight the less must the vanes incline; and when acting on air the quicker must be the rotation, so as to produce sufficient resistance for the vanes to act upon.

These remarks, however, are supposing the air to be perfectly elastic and quick in filling up a vacuum; and as much as deficient in these points, so will the operation lose in effect, or so much larger must the apparatus be. It seems then to follow that a very small force would suffice to *raise* a body by the resistance of the air, *but very slowly;* yet the longer were it continued, the quicker would be the ascent, barring friction, &c. The same applies to cranes and to the starting of carriages. and boats, and to other actions.

In the year 1814 I explained in "The Philosophical Magazine," a machine of paste board, with vanes, which, on rotating rose up in the air, the invention was also claimed by another coreaspondent, signed "Volitor." Some years after this a machine was exhibited on this principle by a gentleman, at the Adelaide gallery, as his own suggestion, though informed that I had published it before, and something similar has been shown at the Cremorne Gardens. It is not howevor to be expected that mankind will ever, by any artificial means be able to fly like a swallow, and if he could, he could not find his way for want of the sense of a bird; let a man once go out of the sight of land without a plumb line, a log book, and compasses, out of his usual track, and he is lost. Nor is it to be expected that the instruments of flight will never have the simplicity and elegance of those of a bird or a beetle. yet if flying can in any degree be accomplished, the advantanges may be great, and hoping it is not too presuming to describe an untried plan of attempting its performance, I have given its description.

N, fig. 8, pl. 10, is a board to stand on; R S and Q T are two uprights fixed in it, the upper parts being united to half a cross, in which the bearings of the works are held; E C and F D are two rods which work in sockets, E and F below, and through other sockets in the middle in the ends of the cross, near L and O. A and B are the floats or instruments of ascension, which are similar to the fly of a smoke-jack, but are a little concave underneath, these radii being bent down like feathers, which seems thereby to give a firmer hold on the air. The vanes of the two instruments must be right and left, (though the drawing by an oversight is not so). G and P are two small grooved wheels, made firm on the rods or shafts, E C, and E D; and H and I are two large *multiplying* grooved wheels which work in the interior cross pieces. Between each of the large and small wheels is a band, and the wheels H and I have each a horizontal handle, which on being turned by the operator, who stands in the middle of the machine, so that the vanes meet the air, a tendency will thereby be given to the machine to ascend. These are only the instruments of ascension, those of progression are two smaller floats L and M placed vertically in the middle of the machine, on which are toothed pinions K K, which being worked by pinions on the shafts; the horizontal and the vertical floats will both revolve together,—the one acting in raising and supporting the machine, and the other to impel it forward. The operator must stand directly under the line of the two floats of ascension; and the two wheels H, I, must be in advance, so that his body remains immoveable, while his arms are at work in opposite directions, one hand counteracting the pressure of the other, without disturbing the body and centre of gravity, and I would prefer to enlarge the wheels H and C, so as to meet and to work by teeth instead of a band. It would not do, as might appear, to have one large float of ascension in the middle instead of one on each side, it would cause the operator to revolve rather than the float, but *two* floats prevents this. When the operator wishes to go straight forward he must stand in the middle and turn both handles alike; but when he has to turn he must work one handle the hardest, leaning to that side that it shall not predominate. A revolving motion has great advantage beyond a reciprocating one, as it saves checks and consequent loss of force, also that loss caused by the air in the up stroke. The material for the vanes has not been considered, but there should be strings or wires C and D from each vane to the shaft to render it strong.

In the drawing, the floats overlap each other (for want of room) but they had better not. Larger floats and a higher speed might also be required than single multiplying wheels could well accomplish, and the drawing is not meant to be exact as to the size of the floats, which must be found by trial, therefore no person must blame the drawing for his not having hit on the proper size in any attempt at practice; but he must find out the proper size for the floats, the proper inclination of the vanes, and the proper speed of rotation to be given. Possibly the floats of progression might be dispensed with, or might be comprised in those of ascension by inclining the fronts of the latter a little downwards, so as to pull against the air, also progressively, if, under these circumstances, the machine could be kept upright.

With respect to the second subject, that of balloons, I have little to offer; the immensity of their size preventing a hope that human strength will ever be able to impel them with tolerable speed against the air alone, much less against the wind, and there being no fixed point as in water to act on; the whole of the air also being in the same motion, no power can be obtained to tack about. There, however, does seem two points which might be improved in the management of balloons, the first being, that they are too much filled with gas, and the second being the adoption of ballast and the discharging of gas, as the chief or only means of raising and lowering the vehicle.

If a balloon is nearly full when down, it is evident that when it gets high in rarefied air, it must expand and probably burst. Let it then be only partially filled, so as to have full room for expansion, and in order that this reduced quantity of gas shall be enough, let the ballast be omitted, so that with less gas and no ballast, the balloon will set off with the same speed as by the common plan, and when it gets into thinner air, the gas will expand it and make amends for the want of density of the air. It seems to matter little whether the air be dense or rare, provided that the internal gas keeps pace with the changes. If a gallon of gas is an ounce less weighty than a gallon of air when near the earth, the same difference will exist above the clouds, and if equally elastic the same buoyancy will exist at every altitude. By this means alone, however, the balloon could only rise, and never come down again, and as the discharging of gas is throwing away the means for another rise, a better way might be found by having an instrument in the car to compress and rarefy the gas by means of a hose communicating within the balloon.

DEFENCE FOR SHIPS AND FORTIFICATIONS *against cannon balls, and causing the balls to fly back against the enemy.*

My plan for causing cannon balls instead of penetrating the ships or fortifications they are fired at and causing them to fly back on the enemy, is as follows :—

Figure 2, pl. 13, is a transverse section of a ship on this plan, protected by oblique surfaces, a and b, all round its sides, the one surface glancing the balls upward and the other downward. These two surfaces form a recess all round the vessel, so curved that when struck, excepting near the middle, the balls will follow its curvature and come out at the other end; and in order to prevent the middle from being struck, it is protected by a more obtuse angular piece, C, round the vessel, and which is fastened to it by several pins at intervals of space; the balls, then, that strike this piece on the recess, according to the well-known law that the angle of reflection is always equal to the angle of incidence, fly from side to side in the decreasing cavity till they reach the recess which conducts them out the other side, so that the balls which strike in the upper part come out at the lower, and *vice versa*, a very slight resistance, when very oblique, being enough to turn a ball. How far this may succeed with cannon is difficult to tell, but in many trials with a blunderbuss, though the substance fired at was soft deal (not cross the grain), it succeeded, and scarcely leaving a mark of the bullet.

In the Philosophical Magazine of Dec. 1823, where a fine engraving in full has been given of the plan, I have treated at considerable length on this subject, and Dr. Jamieson's Dictionary contains a transcript of the remarks which have in other works also been favourably alluded to.

Fig. 3 is a side view (the same letters to the same parts), and fig. 4 is an enlarged section, showing the motion of the balls. Fig. 5 is a section of the plan which presents a longer curve, a, b. C being the end of the board that reflects the balls, which proceed as the arrows show, and the indentation made by the blow of the ball being shown dotted near b.

EXPANDING CHUCKS FOR TURNING LATHES.

These are chucks for a turning lathe which hold different sized pieces of material always in centre.

Figs. 15 and 16, pl. 13, are two perspective views of a chuck, the one holding a large piece, the other a small one, and fig. 17 is one of the jaws: the same letters apply to the same parts.

The body of the chuck, a, is cylindrical and of hard wood, with a screw cut on its periphery, three longitudinal grooves, *b b*, (two only being seen) are made slantingly through its length, shown in dotted lines *c c*, fig. 3. Three clamps, d, e, f, (fig. 17, being one of them) are then placed in these grooves by their jointed ends *g*, by pins through their centres *h*, which pass through the solid back of the chuck *i*, and are rivetted to the hind metallic ring of the same *k*. The clamps move in the grooves (seen in fig. 16), the notched part *l*, is the clamp when open, as in fig. I, and the plain part is the clamp closed, as in fig. 16, and *n* is the body of the chuck. The clamps *d e f* are curved exactly alike, and so as to project above the chuck, and are notched to suit the thread on the chuck, and the ring P O has a thread fitting that of the chuck, and also of the clamps, so that screwing this ring up and down the chuck closes and opens the jaws. And P is a projection with a hole in it by which the ring is turned.

Another concentric chuck which I have to describe (more simple though not so good) is the following, fig. 1, pl. 3.

It acts like a ribbon yard measure, nearly concentricly. A is the body of the chuck, B is the ring (if the chuck be of wood), D is the face in which the cavity is shown, in which a tempered steel spring is coiled; and the face of the chuck has a furrow, F, cut slantingly as shown in it. The part of the spring proceeding from the interior lying in this furrow, while the remaining part of the spring winds round the exterior of the chuck. The end, G, of this spring must be slightly turned up, so as to present a sharp edge, excepting when it would spoil the work, in which case it can be dispensed with. The material to be turned is driven into the chuck so that the edge, G, of the spring gets hold of it; when by twisting round the piece in the proper direction, it coils up more of the spring in the interior while it robs the exterior, and thus the piece becomes tight; it being evident that the more the spring is coiled within the chuck the smaller will be the capacity, and the more it is coiled on the outside the larger will the hole be.

IMPROVED SCREWS.

The threads are perpendicular on the side bearing the pressure, and twice as much inclined as usual on the other sides, friction and the strain to burst the nut are saved by it. (See the Register of Arts, March, 1824.)

NAILS FOR DRIVING INTO STONE OR IRON.

They are of steel imbedded in a thick body of lead, which prevents their bending, while the lead spreads away under the hammer. (See the Mechanic's Journal, Nov. 24, 1838.)

CUTTING AND PUNCHING TOOLS.

On the same principle I have formed an instrument for cutting deep fissures or holes in metal, or separating bars of iron, which are difficult to do with the cold chisel. Figs. 6, 7, 8, 9, 10, and 11, pl. 13, show it in various positions, b, figs. 6 and 11, are a very thin blade or plate of steel, which is defended on the top by a very thick part, a, with slots in it as shown. Fig. 10 is another thick piece with corresponding slots, and with a vacancy to admit the blade b of fig. 11, while the slotted or toothed portions above, fit into each other, and slide up and down. Fig. 7 is a front view of both together, a being the part to which the blade is attached, and e being the cheeks. The lower part, d, is doubly elbowed on each side so as to form a kind of bed to admit of the thing to be cut, and to which it is made fast by two screws, d, the end of the blade, b, being shown in figs. 6 and 9; and fig. 8 is the top of the instrument, a, being the top part of the blade, as in fig. 6 and 11. The material to be cut then in being screwed fast in the jaws of fig. 10, is placed under the blade, and the thick top, a, being struck with a hammer forces the blade through it, which from its own thinness goes through the substance with great ease, as it is prevented from bending in any place. It cannot bend between the jaws, because the jaws and the screws will not admit it, and it cannot bend above, where the blade begins because the teeth, as interlock so that it could not bend there without the thick part doing so too. The parts must be very closely fitted together.

IMPROVED CRUTHCES.

They have two sides which are connected at the top by a concave piece to go under the arms, and at the bottom by a segment of a circle or felloe, the middle having a rail for the hands; they go without raising and sinking the body and with greater speed and ease than common crutches. (See Mechanic's Journal for Nov., 1838.)

NEW BELLOWS.

They consist of a fan revolving in a circular case, drawing the air in through one end of a tube across the periphery, and ejecting it at the other end of it.—Invented and shown in the year 1814. Since which they have been put in practice by another person, and a patent had been obtained by him for the same, but the plan being slightly altered by its drawing in the air through holes in one side instead of by a tube.

NEW PADDLE WHEEL.

This is the same machine as the last, converted into a paddle wheel; the whole tube but not the cylinder being sunk horizontally in the water; the revolution of the fan drawing in the fluid by one end, and ejecting it by the other, while the resistance of the external water would, if I am correct, cause the propulsion of the vessel, and with less loss of force than with the common paddle wheel, because the whole action would be direct, and no water would be raised up by it as with the common one, excepting that which revolved in a circle within the case.

NEW PUMP.

And a third application of this machine is as a pump: water having been raised by it, by immersing only one end of the tube perpendicularly, and the height the water can be raised by its action, is not limited to a certain extent as with the common pump.

STEAM ENGINE WITHOUT A BOILER.

The cylinder being placed within the fire, and water being continually dropped in it so as to generate steam as wanted, safety, economy, and lightness being the objects thereby attained. Mr. Howard, however, has previously adopted a nearly similar plan with spirits, and contemplated to try water. (See "the Register of Arts.")

PERAMBULATOR TO MEASURE A SHIP'S WAY.

This is a little water wheel placed behind a ship which moves an index hand, (Abid.) A plan bearing some similitude has likewise been previously adopted.

SUGGESTION FOR THE CURE OF APOPLEXY.

A bar like a turnpike gate turns round with rapidity, and the patient lies on it with his head near the axle, so that the blood shall be propelled to the extremities by centrifugal force. (See Mechanic's Journal.)

CHIMNEYS AND WALLS OF INCREASED STRENGTH.

The bricks are laid in a zig-zag horizontally instead of perpendicularly. Fig. 2 and 3, pl. 20.

IMPROVED BRICKS FOR WALLS.

They are rhomboidal instead of oblong, so as to interlock like the teeth of two saws, so as not to leave a horizontal line of mortar, and thereby giving more strength.

MODE OF ESCAPE FROM FIRE.

This is by having a balcony along a whole street at the upper stories, without partitions, so that, in case of fire, persons could escape from one house to another.

PEGS FOR VIOLINS, ETC.

Which do not slip back, B B, fig. 8, pl. 1, are the pegs, which are not conical but cylindrical, and they work in holes A A, which are not round, but a sort of oval going taper to the end, the mere winding of the string, then drawing the peg into the small part, tightens it without any other pressure, and when the string is wound up it never gives way or becomes too stiff to move.

IMPROVED PEGS FOR PIANOFORTES.

They are screws with a longitudinal hole through them, through which the wire passes, which have a knot at the end, the wire then can be turned without bending and unbending it so as to break it.

BALANCE LADDER.

Fig. 13, pl. 13. This is a contrivance by which a person can raise himself up and down a building, with very little labour. A B is a rod, at the top and bottom of which are grooved wheels, D and C, in which works an endless band, G F, as in a window blind, on one side, G, of the band there is a weight, E, nearly equal to the weight of the person. He then fixes himself by stirrups on his feet to the opposite side of the band, G, (the side where the weight hangs) and pulls it down alternately with each hand very slightly, which will raise him with speed and ease, if the man weighed 100 lbs. and the weight 99 lbs., he would only have to add about ·2lbs. to rise with speed, and if he were to pull at the rod instead of by the band he would go twice as fast. This invention, however, could only be useful in repeatedly ascending and descending the same building, as the weight would have first to be drawn up and fixed with a catch till let loose by the operator. It is, I understand, now adopted in a manufactory in Bedford.

WRITING SEVERAL COPIES AT ONCE.

This consists merely in fixing many points together like a harrow or three legged compasses, each being the distance of a sheet of paper from the other, a pen or pencil is then affixed on every point, and the whole instrument is then held by the hands and written with, taking care not to turn it round; and then each point will make a copy like the other. (Penny Mechanic, May 21, 1842.)

WATCHES AND CLOCKS WITHOUT CHAINS AND FUSEES.

Figs. 21 and 22, pl. 13. There is a steel spring wound round one cylinder by one end, the other end being wound round another of the same size, in an opposite direction, so that as they turn the spring winds on one and off the other, or *vice versa.* The force then that the one exerts on the other will never vary, or the plan may be varied so that the spring should bend in the same direction on both wheels, each end of the spring would then wind the same way, but then one wheel must be larger than the other, so that the spring inclined to be on the one which strained it the least, and by uncoiling on the one and coiling on the other, would turn the wheels.

METHODS OF DRAUGHT BY HUMAN LABOUR DRAWING POLES AND SPIKED SHOES.

Fig. 2, Pl. 12, are two plans to enable a man to draw a carriage or a barge, &c., with more force. The drawing poles are two poles twelve feet long, with a bent spike in the ends; one of these being held in each hand, and the man being tied to the weight, he places the poles behind him, and pulls against them alternately, by which means he uses all his four limbs like a horse, and greatly increases his power, spikes in the shoes also greatly add to the effect. Few, even good mechanics, understand the act of drawing, they think that their own weight acts like a counter weight to the one drawn as with a pulley, and that the weight an animal can draw is measured by the weight of its own body; but this a great mistake, as no weight can produce motion unless it descends. The animal, it is true, requires his weight in draught, and could not draw an ounce without it, still the weight has nothing to do with the draught, in the way generally conceived. All the use of the weight is first to produce friction in the feet, and secondly to keep the animal from rising up, but which could not take place if the weight were able to be tied to him near to the ground. (Suggested about the year 1805.)

The power of draught in men may be greatly augmented by the following means :—

It has been supposed that a man who weighs 140 pounds, could only act against 27 pounds at breast-height, when walking forwards, and 70 pounds walking backwards; but this is not the case—though the more the weight to be drawn, the more must the same man stoop, and the action depends on his strength.

The comparative loads which have been raised by a man, aged 23, whose weight was 132 pounds, (less than 9½ stone) but rather out of health at the time, from my own personal trials or performace, has been has follows :—

With the drawing poles, without spiked shoes, 112 pounds were raised 7 feet, (the whole depth of the place) and 168 pounds were raised one foot, without allowing another step. But with the spiked shoes, in adddition to the poles, 168 pounds were raised the whole distance, and 224 pounds were raised one foot. In walking backwards, or even forwards, 56 pounds were raised the whole distance, and 112 were raised one foot, though (the weight of the drawer was 8 pound less than 140 pounds) still more may be done in the action of turning a mill or a crane by fixing a circular ladder horizontally near the ground, and by the person moving on this with hands and feet, with the shaft of the mill or crane attached to him. By this method, with a straight ladder, fig. 2, pl. 19, 290 pounds were raised to the top, and a weight which seemed to be 548 pounds was raised from the ground; all of these with the same velocity as that of the person's own motion. But this action I found too fatiguing to continue, though by substituting a rail on each side for a ladder so as to be grasped with the hands, fig. 2 pl. 19, 168 pounds were raised to the top, 224 pounds were raised half-way, and 56 pounds were raised 7 feet in about the first second and a quarter, the speed of which would doubtlessly increase as the action continued; and when spiked shoes were added, if I am correct, 224 pounds were raised to the top. In both these plans, B is the pulley, and E the weight to be raised. A being the rope, attached to the man's shoulders. A single rope *in a straight walk*, fixed opposite to pull against, will do instead of rails, and this use of a rope has been alluded to in the Royal Academy of Sciences, at Paris. In my experiments, however, I had the friction of two pulleys also to overcome; but still greater weights were raised by other methods inapplicable to draught.

The weight a horse can draw out of a well is stated by W. Emerson to be 200 pounds at 2½ miles per hour, for 8 hours per day, or 240 pounds for 6 hours per day, though not quite so fast; but it could, doubtlessly, draw much more if its feet did not slip.

In estimating the power of a person or animal in draught, it has been a common error to consider the weight of a person, &c., as a counterpoise to the weight raised; but this is evidently wrong, because the person does not fall as the weight rises, but moves horizontally while the weight moves vertically.

UNTRIED SUGGESTION FOR SPEEDILY DRYING LINEN, &C., WITHOUT THE RISK OF SCORCHING.

It has occurred to me that probably linen, &c., might be almost instantaneously dried, free from scorch, by being placed in an air-tight case, with a spout, and then pumping the air out with an air-pump,—in which case, it is presumed, that the wet on the linen would pass off with the air through the spout; as it is known, that on the pressure of the atmosphere being removed from water, the water boils and evaporates in common temperatnre.

REMARKS ON MUSICAL STRINGS AND INSTRUMENTS.

It is known only to few persons that in strings of the same material and quality no perceptible difference exists in the height of the pitch to which they can be tuned: a string of a bass, if put on a violin, could be drawn up to the violin pitch, and would break at the same note as a violin string would. If in playing either should be inclined to break soonest it would be the *thin* one, owing to the pressure of the bow; and the reason why all such strings break on the same note is because a thick string is only like a number of thin strings joined, each having its proportionate tension to the whole, and if the whole string could be split into any number of parts each filament would sound the same note as the original; or if a string much thicker than another were drawn up to the same note, it would require as much more force as it has in size to tune it, though both would be equally stretched; if it require one coil round the peg to draw a string up to one note and two to another of the same quality, it would take one coil with another however thick or thin; and never would the thickness cause any difference, however contrary to the general belief this may be.

All the strings then of a violin being equally long, the first string is the most stretched, and this causes the high strings to have a better tone than the lower ones; being more elastic, it being impossible to stretch the lower strings as much without drawing them up to the very same note, and if the lower strings are made still thicker they become two stiff, without being in the least more on the stretch; what the lower strings require is greater length, and this in violins they cannot have. In the double bass the first string requires a great many turns to draw it to the pitch, and the third though much thicker, very few, the tone consequently becomes too abrupt and in-elastic, and in bow instruments a thick string is apt to divide itself into the harmonic nodes instead of producing the full note, but in harps and pianofortes this defect scarcely exists, as there is room for the length of the strings to be in proportion to the note, but being longer they are improved by being thicker too, yet do not owe the bassness to their thickness.

When the note we want is very low, and we cannot add to the length, the only way is to *load* it without adding to its strength, the load then making the vibrations slower, making the note still more bass than we want, when, by winding it up tighter we draw up it up to the proper pitch so as to give more elasticity to it, though not so much as with the high string. But if strings were perfectly elastic, no covering or loading would be required, and then good bass notes could be produced with short strings, as is done in musical boxes and accordions with short springs.

It seems that the same notes from strings of the same material are better the longer they are, and the length they can admit of depends on their strength, their specific gravity, and their elasticity. Steel and iron then being the strongest and lightest metals and very elastic, are used for the treble notes of pianofortes, but are not so good for the bass notes, because the instruments are too short, the bass strings, therefore, are in some instruments of *brass;* which has less strength and more weight than steel or iron, and thus resemble a steel or iron string *loaded;* and in short pianofortes even brass is too stubborn for its weight, and therefore, the lowest notes are covered. The first string on the violin is considerably longer for the note it produces, than any string on any instrument of the violin kind, which though it renders the tone more brilliant causes much breakage of strings. In the tenor the first string is the same note as the second of the violin, but being longer, this adds to the tone. Of the violoncello the strings are shorter than of the violin, according to their notes. On the double bass the first string is longer, according to the note, than the first of the violoncello, the second shorter, and the third shorter still. The neck of the instrument also being shorter, and the strings not answering well when covered, causes that this instrument, though so much larger only goes a note and a half below the violoncello, though its notes are often mistaken, from their deep tone, to be an octave lower than they are; and indeed the notes are generally taken on it an octave below the violoncello part. In the harp, the body of the instrument being very small for bass notes, it gives less aid to the string than does the violoncello, greater length of string is therefore adopted, the lowest C on the harp being just twice the length of the lowest C sharp on the violoncello, only half a note above, so that this harp string is drawn nearly twice as tight as that on the violoncello; though the former is only of silk and the latter of cat-gut, yet it does not often break. The pitch to which any material can be drawn before it breaks is a true criterion of its strength in proportion to its weight, and the more a string is on the stretch the more equal will be the tone of every part of the same vibration. In pianofortes the strings being of *metal* they are much shorter than of the violin, which are *cat-gut*, which is more yielding. The thickness of a string also affects its quality though not its pitch, thick strings touch most air, therefore a thick string of a light material seems better than the reverse, and this also may be in favour of covering the string, though it *increases* the *weight* and *decreases* the *strength*.

There seems to be some mistake entertained as to the degree of depth and height at which notes can be discerned. There are no doubt, limits, but not those generally imagined, the present limits being more owing to the fault of the means than to the incapacity of the ear to distinguish tones. Persons usually think when they find the very low notes of a pianoforte, &c. bad, that these notes are too low to be good, but this is far from the case, the reason is that the strings are too short, and the belly, &c. of the instrument too small, and when extreme treble strings are bad it is because the belly, &c. is too large. Here we have the remedy in our own hands, to improve the bass notes by lengthening and thickening the strings, and increasing the sounding board, but if the sounding board is too large it is too bulky to be shaken by them, and when found that the high notes break, it is because they are too long for the pitch, though the longer the string of every note is the better. Small seraphines produce very fine notes, as low as the lowest notes which are not good on the pianoforte, and go down to C, six and a half notes lower than the lowest note of the double bass.

But the tone of a note is not all owing to the string's own vibration against the air, this in fact causing but the smallest portion of it, as may be proved by the weakness of the tones of a mere string, however stretched, without having a body to rest and act on, the chief of the tone being the effect of the body itself; which, acting against so much broader a surface of air, does more execution than the string itself, though its length of vibrations are much less. A string in vibrating on an instrument is no where at rest: not even at the nut, and the bridge; and it is the part resting on the bridge which produces the chief effect; if they did not move, it would be of no use, but as the string vibrates the the bridge and nut resist, and the feet of the bridge resting on the belly which is of thin yielding wood, communicate some momotion to it which in violins, &c., is communicated also to the back and sides by means of the sound post, which, (for what reason I know not) is omitted in the harp, the guitar, and the pianoforte. The confined air in the interior also helping the effect, the whole body then vibrates with every note, and even with chords, and so increase the tone; not it appears as is generally imagined, because it is *hollow*, so as to cause a reverberation and echo. but merely because it presents a larger surface to the air. It is admitted that sound is increased in a hollow confinement, by means of reverberation, yet this increase, it seems, only affects the ears which are *within* the place, (not those of persons outside.) The motion of the body, however, is very different from that of the strings, the first being small in distance of vibration, and large in surface; the latter long in distance and small in surface: a great pressure would be rerequired to stop the vibrations of the body, while a slight touch would stop those of the string. The body may be compared to a fan, which if moved in air or water would cause much disturbance, but the string is too small to have much effect.

With respect to the quality of an instrument little is known theoretically, and the best masters have chiefly been guided by trial and experience, but there seems to be a certain size, quality, and thickness of wood, best adapted to every instrument; and on this it seems mainly to depend. We find that some notes on an instrument are much better than others, nearly of the same pitch, the reason of which appears to be the following:—every body of an instrument has a sort of a *note of its own* when struck, like with a drum, if then, the note of the string is the same note, or a near chord of the same, the string and the body agree together to produce the same note, but if the discrepancy is great, as between A and A sharp, the body and the string will quarrel. But though its body has a note of its own, it gives aid to other notes and even to chords.

Attempts have been made to improve the tone of violins &c., by having additional strings under the ones played on; to respond to their vibrations, but if any advantage exist in this, it must only be because the additional strings are not interrupted by the bow and the rosin, which with the finest players even must always cause a slight grating against the string, as the bow goes only one way during a note, while the string goes backward and forward, half of the vibrations being thereby opposed instead of assisted by the bow; so that the wonder is that it should sound at all, the only surmise is, that when the string is drawn out of its line, and the bow goes beyond the spot, the string springs back with a jerk that defies the controul of the bow. Additional strings, however, it seems, cannot add power to the tone (except from this cause), because though they sympathise with the original strings, they are only pulled to and fro by means of the air itself; and it is plain that if the air move the string, the string cannot move the air; we might as well suppose that two men might lay hold of each other, and run so as to pull each other on at the same instant. The additional string is in fact a *clog* to the other, though not so much so, as if the additional string could not vibrate; and any body in the neighbourhood of a vibrating body tends to stop its motion.

SUGGESTION TO PRODUCE A FIRE-PROOF BOX.

That this suggestion would succeed, I am far from trusting to, but as possibly it might to some extent do so, it may not be amiss to describe it untried. The box is made of steel, &c., highly polished, as polished metals reflect back the heat as well as the light that are cast upon them, this box is then put into a much larger air-tight case of iron, and has legs of thin wire to prevent its touching the outside case, and all the air is pumped out so as to leave a vacuum between the two boxes, and so that no heat can be conveyed to it by the contact of air, and as the radiant heat is rendered harmless by the polish and the heat of contact is prevented by the vacuum, it seems that the heat is kept out entirely, excepting through the small wire legs.

A LIGHT, STRONG, AND CHEAP BOW FOR A VIOLIN, &C.

In common violin bows the tightening of the hair bends the stick; but in my plan, about to be described, this is not the case; and therefore the stick may be lighter and the hair more tense than usual; lightness and strength being most important in bows. Figs. 8 and 9, pl. 19, show the bow in two views. A B is the stick, A the handle, C the hair, and D F a string to which the hair is attached—which string passes over a grooved block E, the other end being wound round a peg D, held in another open block D, with a V-shaped hole in it to keep the peg from slipping. The tightening of the hair is then done by winding up the string, and as the string and the hair draw equally on opposite sides of the stick, however tight the hair may be wound, the stick cannot, if straight, be bent by the tightness. Two little rollers in the block E, would aid the plan if the weight were not thereby much increased. And F is a grooved pillar near the middle of the stick, through which the string passes to give lateral strength. This bow is most suited for the violin, but for the violoncello its advantage is not so great, because violoncello bows are used rather sidewise, and then when wound tight are inclined to give way by lateral pressure, but for the double bass it would, it appears, be also very advantageous, provided their present wide handles were preserved. The mode of tightening the hair by means of a peg is likewise more simple and inexpensive than by a screw; and soft light wood for the stick, as it admits of being thicker than hard woods, also seems to offer greater strength in proportion to the weight.

METHOD OF PRODUCING A STRONG JOINT IN MATERIALS WITH A WEAK CEMENT, AND SOLDERING WOOD TOGETHER.

The pieces are shaped as in Figs. 10 and 11, pl. 20, into a convex and concave triangle. Even sealing-wax will join wood tolerably strong in this way.

Figs. 12 and 13, pl. 20, shows how to dovetail two pieces of wood by soft solder. A B is a countersunk hole into which the fused metal is poured.

A LIGHT AND PLIANT ARMOUR FOR MEN AND HORSES.

This is by plates of tempered steel, properly shaped, being sewn on the clothes. Soft iron would perhaps be better than steel against a thrust of a sword or bayonet, because the point would impinge on it, and thus be kept from slipping into the joints.

HINTS TO WORKMEN.

To Vice-men, &c. when anything has to be filed which is so delicate and so shaped as not to bear being held in the vice, screw the file in the vice by the handle, and hold the piece in the hands, rubbing it on the file. The same applies to soft soldering, it being often necessary to screw the soldering iron in the vice, holding the piece to be soldered in the plyers, &c.

To Hammermen.—If you wish to strike firm and quiet blows on the anvil, employ an anvil *without a beak*, as the vibration of the beak causes a ringing, and seems to prevent a dead blow, but it may be nearly stopped by placing a weight near the end of the beak. It is also desirable to get rid of the useless and pedantic practice of striking the hammer on the anvil between every two or three blows on the piece, as it is a waste of labour, spoils the tools and makes an offensive noise: smith's should learn to keep time without.

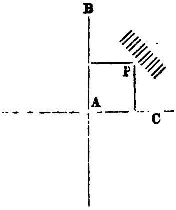
To Turners.—A weight fastened on the rim of the fly wheel in opposition to the treadle, will equalize its power and give it greater effect.

I have also found that water may be raised by means of the revolution of an inverted funnel, the base of which is covered with vanes like in a smoke-jack. The same might possibly serve as bellows; but not in this case without it revolved with very great velocity.

NEW PLAN TO IDENTIFY STREETS AND HOUSES.

BY BENJAMIN GOMPERTZ, ESQ.

This is an ingenious plan of identifying streets and houses. The plan is to annul the names of streets, and also the present mode of numbering houses; so that any house in any situation may be known without any other direction than the following which, of itself, directs to the place without inquiry.



Mr. B. G. observes that "for the map of a city my proposal is to draw two lines, A B, A C, perpendicularly to each other; the one A B, from north to south, the other A C, from east to west, each to be divided in equal parts representing some small measure, as 100 feet or 100 yards, &c. as may be agreed on, to be denominated City Degrees, these to be divided into 100 parts called City Minutes, and so on for smaller divisions. The point A, from whence these measures are to be taken, should be some principal point, say the centre of the City. The measure on A B, to be called the latitude, north or south, according to which side of A it lies; and that on A C, east or west, according also to which way it lies. A survey should be taken of the City and the measure from those lines should be taken to every house, P, giving what would be called the City Latitude and City Longitude of that house, and should be fixed on the house in lieu of a number. It may be necessary to enter more fully in detail if the plan is to be adopted, but what I have said will be sufficient for the present. It is a great many years since I have thought of this plan, but to me it appears useful." The street should be named by the latitude and longitude of some point in it, by a plan easily explained, which want of time prevents at this moment.

REMARKS ON SADDLES.

All riding-saddles are possessed of two objectionable qualities, the first being that they allow the back bone of the horse to bear the strain of the weight; to avoid this, a spring bar might probably be applied so as to bear only on the haunches and shoulders, leaving the middle hollow; ease would thereby be given to the rider as well as the horse—provided it was not found to interfere with the motion of the limbs.

The second defect is in the *girthing*, which is necessarily injuriously tight, to prevent the saddle from slipping round in mounting, and is drawn, by means of the swivel or roller in the buckle, with double the force applied to fasten the band or is equal to about 200lbs. weight. To prevent this entirely seems impossible, but the way to reduce the pressure probably is the following: let a band be first applied moderately tight round the horse, and to this let another band be attached, so long as to go two or three times round its body, and to this the saddle, if it can, is to be affixed; the effect of which would, it is presumed, be to cause the tightness to be only while mounting, and when not, the only pressure being from the first-mentioned comparatively slack band.

HINTS TO CARMEN.

It is a common practice with Carmen to place more load on the front (small) wheels of their waggons than on the hind ones, on the idea that their being nearer to the horses the draught will be the less, but this is very erroneous, and any one may convince himself of this by letting one man or horse pull a waggon at one end with a short rope and another horse or man of equal strength with a long rope at the other, and it will be seen that they will pull with equal effect, and the waggon will not move.

ERRATA.

In line six from the bottom of page 9, for "groves," read, "grooves;" and, in line four from the bottom, for "heft," read, "left."

In lines seven and eight from the bottom, page 14, for "the middle and," read, "the middle, the middle, and"

A Drawing of the crutches alluded to in Page 64 will be found in Plate 13.

In Plate 15 there are two parcels of stones which, by mistake, have been drawn much too large, one being near fig. 13 and the other near E.

Pages 13 and 14 should be 11 and 12, and so on.

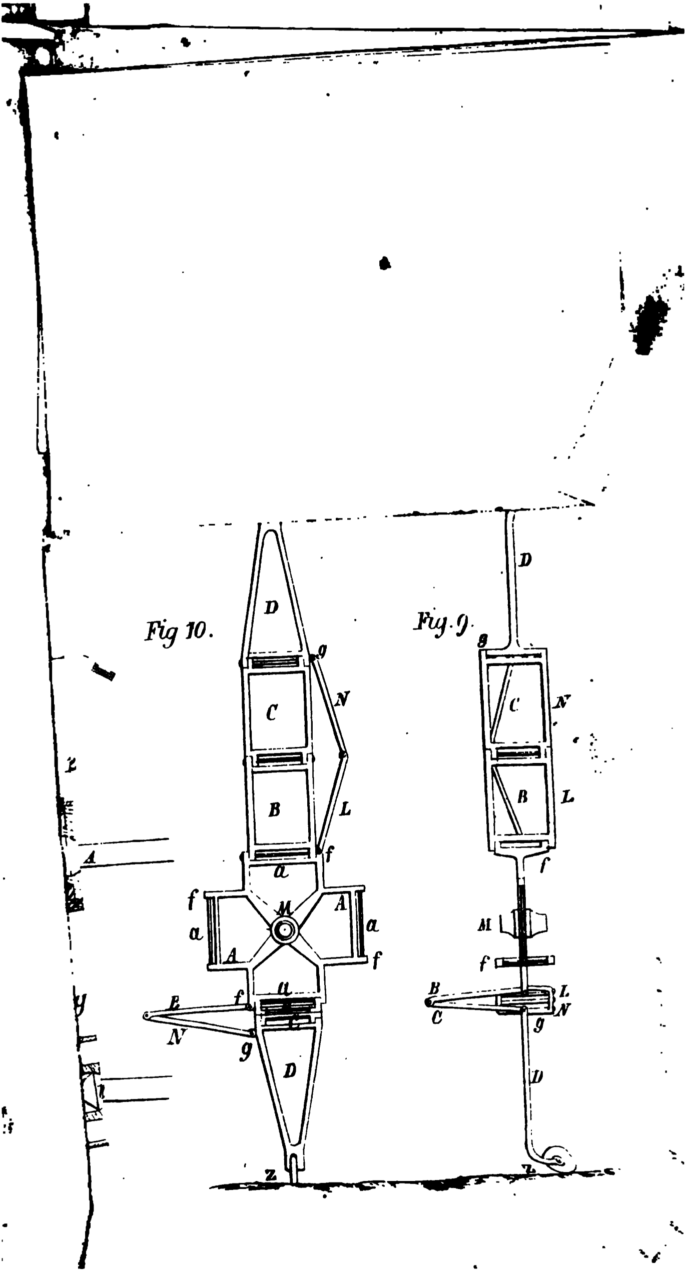


Fig 10.

Fig. 9.

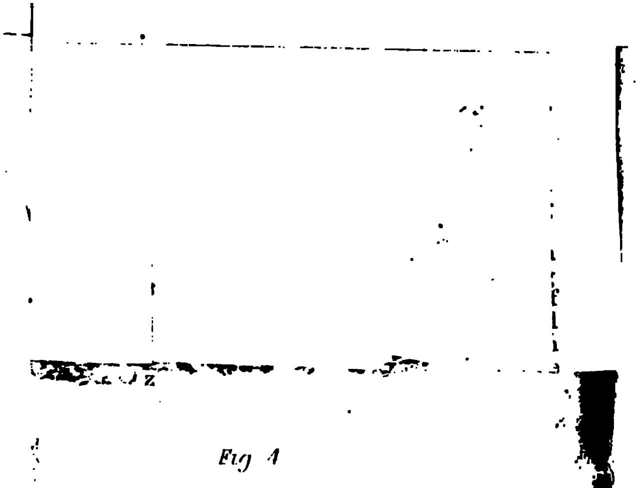
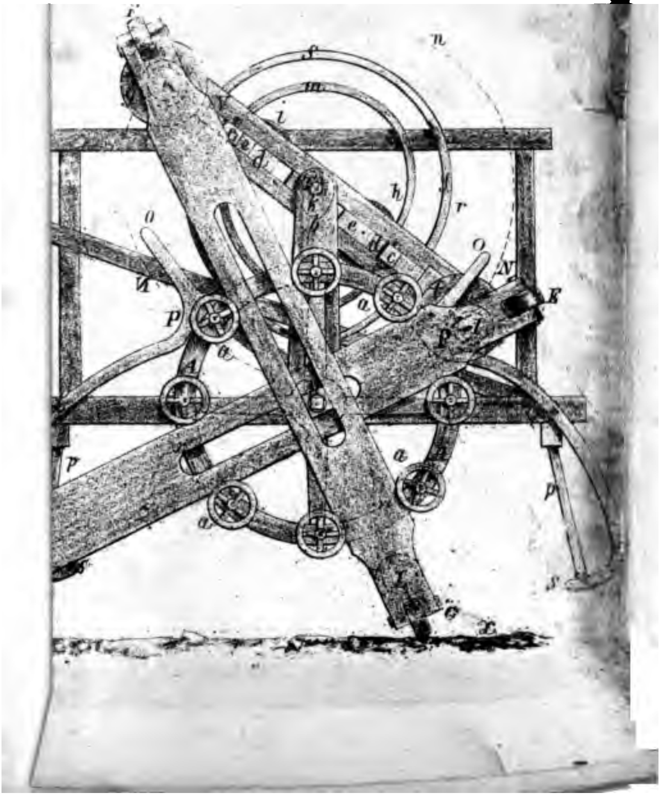


Fig 4



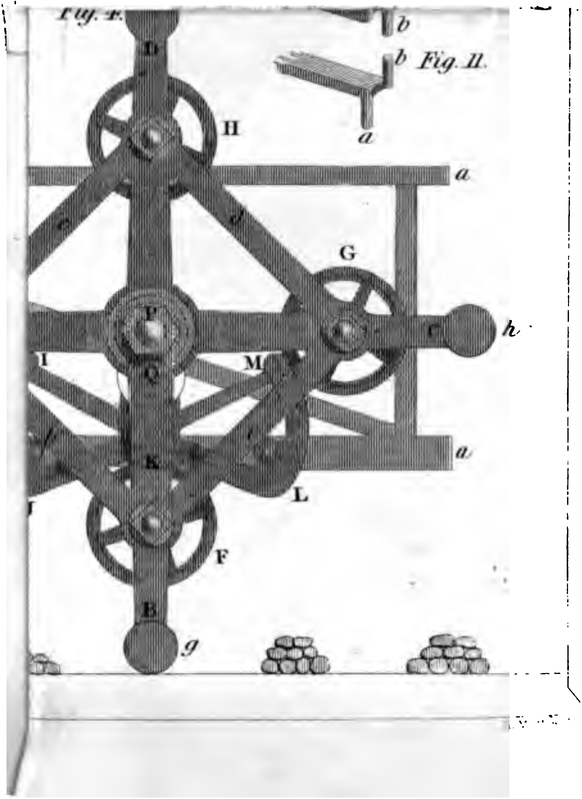


Fig. 4.
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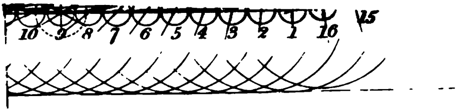


Fig. 4.

H. Mutlow sculp.

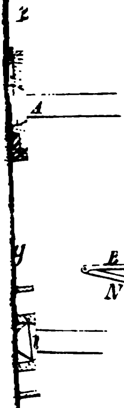


Fig 10.

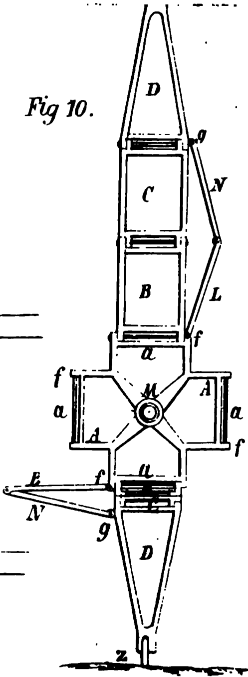
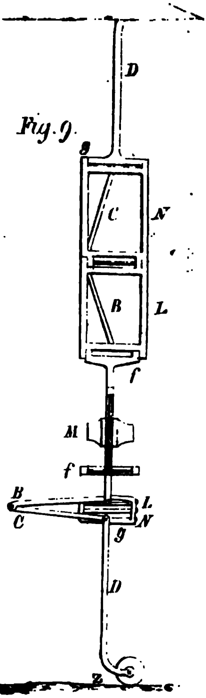


Fig. 9.



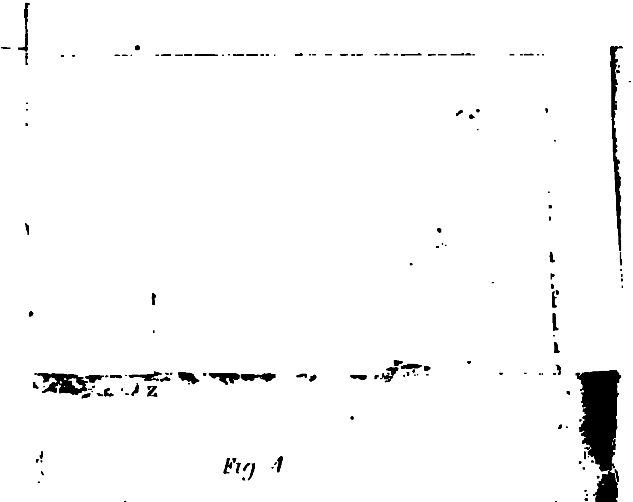
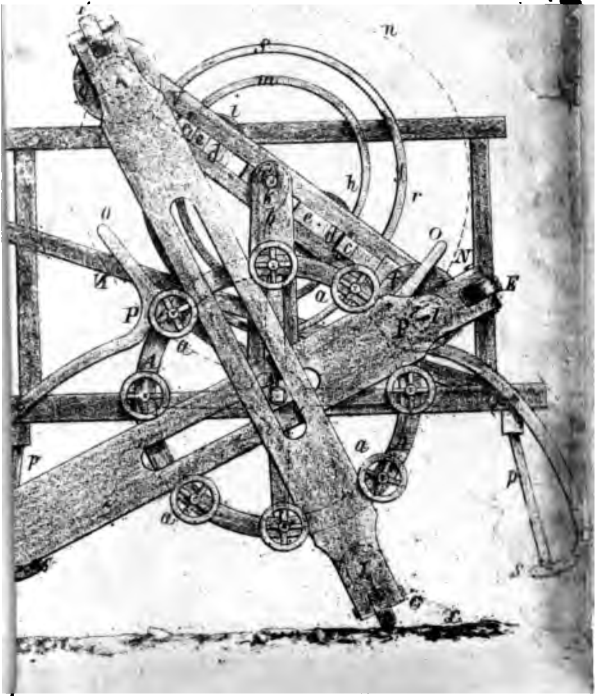


Fig 4



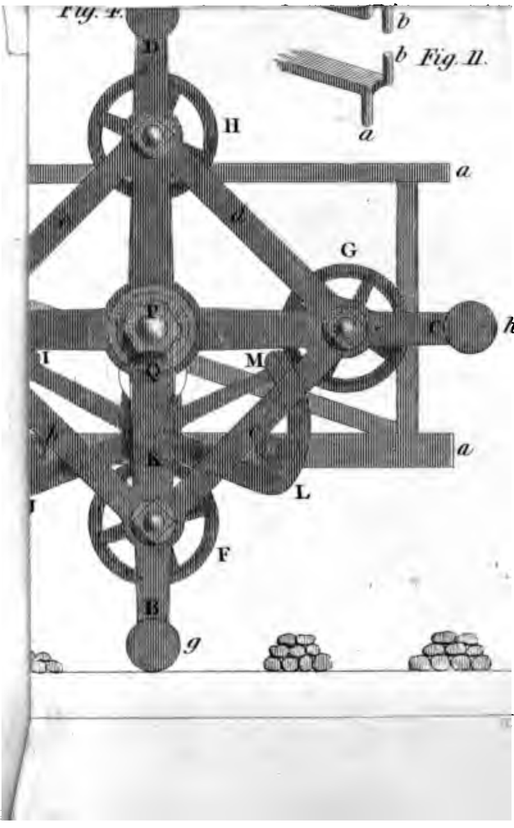


Fig. 4.
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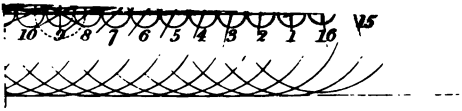

Fig. 4.

H. Mutlow sculp.

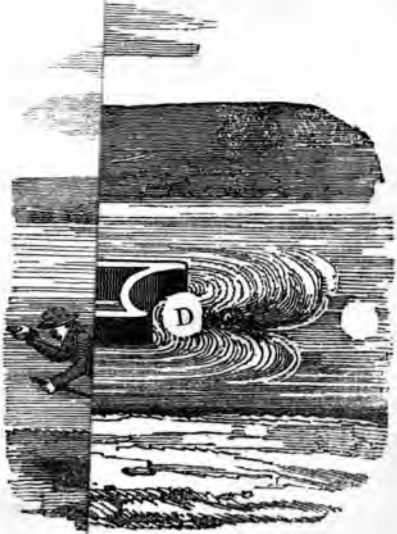
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PLATE 14.

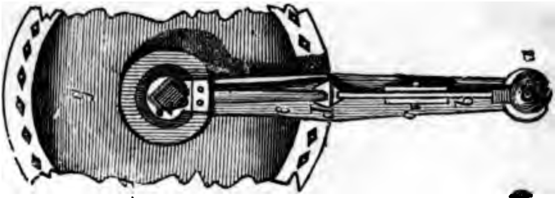


Fig.

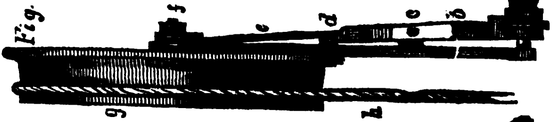


Fig. 3.

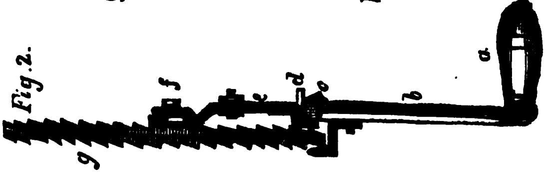


Fig. 2.

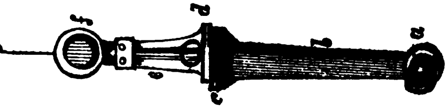
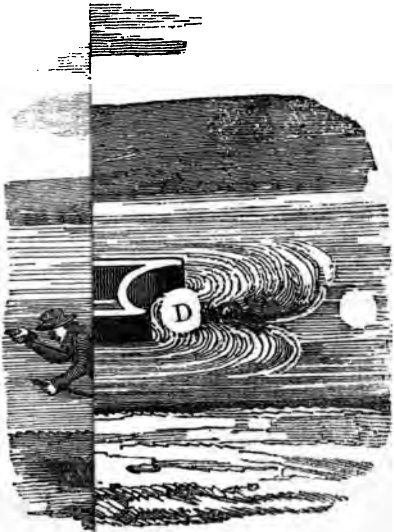


Fig. 1.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